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June 26, 2012

Brandon Perkins, Task Monitor
United States Environmental Protection Agency
1200 Sixth Avenue, Mail Stop ECL-112
Seattle, Washington 98101

Re: Contract Number: EP-S7-06-02
Technical Direction Document Number: 12-04-0001
Flint Hills Resources North Pole Refinery Preliminary Assessment Report

Dear Mr. Perkins:

Enclosed please find the Preliminary Assessment Report for the Flint Hills Resources North Pole Refinery, located in North Pole, Alaska. If you have any question regarding this submittal, please call me at (206) 624-9537.

Sincerely,
ECOLOGY AND ENVIRONMENT, INC.

Linda E Ader

Linda Ader
START-3 Project Leader

cc: Jeff Fetters Project Manager, E & E, Seattle, Washington

Preliminary Assessment Report
Flint Hills Resources North Pole Refinery
North Pole, Alaska.

June 2012

Prepared for:
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
1200 Sixth Avenue
Seattle, Washington 98101

Prepared by:

ECOLOGY AND ENVIRONMENT, INC.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

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List of Abbreviations and Acronyms

ADEC	Alaska Department of Environmental Conservation
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BTEX	Benzene toluene, ethylbenzene, and xylenes
BWT	Below the Water Table
CSM	Conceptual Site Model
CU	Crude oil processing unit
DRO	Diesel range organics
E & E	Ecology and Environment, Inc
EPA	Environmental Protection Agency
EU	Extraction Unit
F	Fahrenheit
Flint Hills	Flint Hills Resources
GAC	granular activated carbon
IRAP	Interim Removal Action Plan
JP4	Military jet fuel
LNAPL	Light non-aqueous phase liquid
MAPCO	MAPCO Petroleum Inc
NAPL	Non-aqueous phase liquid
NPR	North pole refinery
PA	Preliminary assessment
PQL	practical quantitation limit
SC/CAP	Site characterization/corrective action plan
SCWP	Site characterization work plan
START	Superfund Technical Assessment and Response Team
TDL	The target distance limit
UST	Under Ground Storage Tank
WELTS	Well log tracking system
µg/L	Microgram per kilogram

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1 Introduction

Ecology and Environment, Inc. (E & E), was tasked by the United States Environmental Protection Agency (EPA) to provide technical support for completion of a Preliminary Assessment (PA) at the Flint Hills Resources (Flint Hills) North Pole Refinery (NPR) located in North Pole, Alaska (Figure 1-1). This PA report focuses on sulfolane, which was discovered in ground water near the site in May 2001 (Shannon & Wilson 2001). E & E completed PA activities under Technical Direction Document Number 12-04-0001, issued under EPA, Region 10, Superfund Technical Assessment and Response Team (START)-3 Contract Number EP-S7-06-02.

The specific goals for the Flint Hills PA, as identified by the EPA, are to:

- Determine the potential threat to public health or the environment posed by the site;
- Determine the potential for a release of hazardous constituents into the environment; and
- Determine the potential for placement of the site on the National Priorities List.

Completion of the PA included reviewing existing site information, collecting receptor information within the range of site influence, and determining regional characteristics. This document includes a discussion of background site information (Section 2), a discussion of migration/exposure pathways and potential receptors (targets; Section 3), summary and conclusions (Section 4), and a list of pertinent references (Section 5).

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2 Site Background

2.1 Site Location

Site Name:	Flint Hills Resources North Pole Refinery
CERCLIS ID Number:	AKD000850701
Site Address:	1100 H & H Lane, North Pole, AK 99705
Latitude:	64^{o} 44' 13.96" North
Longitude:	147^{o} 20' 53.51" West
Legal Description:	Township 2 South, Range 2 East, Sections 16 and 21
County:	Fairbanks North Star Borough
Congressional District:	At Large
Site Owner(s):	Flint Hills Resources 4111 East 37th Street N. Wichita, Kansas 67220
Site Operator(s):	Flint Hills Resources, North Pole Refinery 1100 H & H Lane North Pole, Alaska 99705

2.2 Site Description

Flint Hills operates a petroleum refinery, the NPR, in North Pole, Alaska. The refinery was purchased by Flint Hills from Williams Alaska Petroleum, Inc., in 2004. The NPR is located outside the city limits of North Pole, approximately 13 miles southeast of Fairbanks, Alaska (Figure 1-1). Flint Hills occupies approximately 80 acres on a parcel that is approximately 240 acres in size. The refinery, parcel boundaries, nearby roads, and surrounding areas are shown on Figure 2-1 (Barr 2012). The layout and features of Flint Hills, including site structures, process units, aboveground storage tanks (ASTs), and tank farm containment areas, also are shown on Figure 2-1.

Three crude oil processing units (CUs) are located in the southern portion of the refinery. These units make up the process area of the refinery, with CU #3 being the newest, having been constructed in 1998 (ADEC 2010). Tank farms and associated containment areas are located in the central portion of the refinery. Truck loading racks are located immediately north of the tank farms, and a railcar-loading rack is located west of the tank farms. Previously, a truck-loading rack was located between the railcar loading rack and the tank farms near the intersection of Distribution Street and West Diesel (Figure 2-1; Barr 2010; Barr 2012).

Wastewater treatment lagoons, storage areas, and two flooded gravel pits (the North and South Gravel Pits) are located on the western portion of the property.

With the exception of rail lines and access roads, the northernmost portion of the property is undeveloped (Figure 2-1; Barr 2010, 2012).

Spills of product used at the NPR into or on land from refinery operations over the plant's history have been documented. These spills have occurred from leaking storage tanks, leaking sumps, overflow of the wastewater handling pond, and certain handling procedures (ADEC 2012). Sulfolane, a product used to refine gasoline, has been used at the site since 1985, prior to Flint Hills's purchase of the facility (Barr 2012).

Sulfolane was detected at concentrations ranging from 31.6 to 229 micrograms per liter (µg/L) in 15 off-site monitoring wells installed in September and October of 2009. Since 2009, Flint Hills has performed ground water monitoring utilizing both monitoring wells and private drinking water wells. This monitoring has revealed a dissolved-phase sulfolane plume approximately 11,000 feet at its widest point and extending approximately 3 miles northwest of the NPR (Barr 2012). The extent of the dissolved-phase sulfolane plume is depicted in Figure 2-2.

2.3 Ownership History

The property was originally developed by Earth Resources, who produced its first barrel of petroleum product in August 1977, just two months after crude oil began to flow through the Trans Alaska Pipeline (ADEC 2010). MAPCO Petroleum, Inc. (MAPCO) bought the plant in 1980 and expanded production to include gasoline and asphalt in addition to jet fuel and heating oil. MAPCO merged with the Williams Companies (Williams Alaska Petroleum, Inc.) in 1998 and then sold the facility to Flint Hills Resources in 2004. Currently, Flint Hills has a crude oil processing capacity of approximately 220,000 barrels per day (ADEC 2012).

2.4 General Refinery Operations and Waste Characteristics

As stated above, Flint Hills receives crude oil from the Trans-Alaska Pipeline and has a crude oil processing capacity of approximately 220,000 barrels per day (ADEC 2012). Flint Hills processes North Slope crude oil to produce and supply gasoline, jet fuel, heating oil, diesel, gasoline, and asphalt to Alaskan markets. A general list of operations at the NPR was located; however, detailed descriptions of these operations could not be found (Shannon & Wilson 2006; ADEC 2012). In general, it is known that refinery operations include desalting, atmospheric distillation, vacuum distillation, and aromatic extraction (Shannon & Wilson 2006; Barr 2012).

Petroleum refining is the physical, thermal, and chemical separation of crude oil into its major distillation fractions, which are then further processed through a series of separation and conversion steps into finished petroleum products. The primary products of the industry fall into three major categories: fuels (motor gasoline, diesel and distillate fuel oil, liquefied petroleum gas, jet fuel, residual fuel oil, kerosene, and coke); finished nonfuel products (solvents, lubricating oils, greases, petroleum wax, petroleum jelly, asphalt, and coke); and chemical industry feedstocks (naphtha, ethane, propane, butane, ethylene, propylene, butylenes, butadiene, benzene, toluene, and xylene) (EPA 1995).

Crude oil is a mixture of many different hydrocarbons and small amounts of impurities. The composition of crude oil can vary significantly depending on its source. For these reasons, no two refineries are alike. Refining crude oil into useful petroleum products occurs in two primary phases and a number of supporting operations. The first phase is desalting of crude oil and the subsequent distillation into its various components, or "fractions." Once desalting and distillation have taken place, a second phase of downstream processing is performed (EPA 1995). In general, the first phase of desalting and distillation is the same for most refineries, but the downstream processes can differ from refinery to refinery, based on the age of equipment and technology used at the refinery. Below is a description of the operations performed at the NPR.

Crude Oil Desalting and Distillation

Desalting: Before separation into fractions, crude oil usually must first be treated to remove corrosive salts. The desalting process removes salts, water, and other impurities from the crude oil before it is sent to the crude distillation units because some of the metals and suspended solids cause catalyst deactivation (Shannon & Wilson 2006; EPA 1995). Desalting involves the mixing of heated crude oil with water (about 3 to10 percent of the crude oil volume) so that the salts are dissolved in the water. The water must then be separated from the crude oil in a separating vessel by adding demulsifier chemicals to assist in breaking the emulsion and/or, more commonly, by applying a high potential electric field across the settling vessel to coalesce the polar saltwater droplets (EPA 1995).

Downstream Processing

Atmospheric Distillation: Using atmospheric distillation, desalted crude oil is separated into gas, naphtha, light distillates, gas oil, and reduced crude (Shannon & Wilson 2006). This process involves heating desalted crude oil in a heat exchanger or furnace to about 750 degrees Fahrenheit (F). It is then fed to a vertical distillation column at an atmospheric pressure in which most of the feed is vaporized and separated into its various fractions by condensing on 30 to 50 fractionation trays, each corresponding to a different condensation temperature. The lighter fractions condense and are collected towards the top of the column. Heavier fractions, which may not vaporize in the column, are further separated later by vacuum distillation (EPA 1995).

Vacuum Distillation: Heavier fractions from the atmospheric distillation unit that cannot be distilled without cracking under its pressure and temperature conditions are vacuum distilled. Vacuum distillation is simply the distillation of petroleum fractions at a very low pressure (0.2 to 0.7 pound-force per square inch absolute) to increase volatilization and separation. In most systems, the vacuum inside the fractionator is maintained with steam ejectors and vacuum pumps, barometric condensers, or surface condensers. The injection of superheated steam at the base of the vacuum fractionator column further reduces the partial pressure of the hydrocarbons in the tower, facilitating vaporization and separation (EPA 1995). Asphalt is produced by vacuum distillation at the NPR (Barr 2012).

Aromatic (Sulfolane) Extraction: The lighter fractions (naphtha and light distillate) from the atmospheric extraction unit (EU) are sent for aromatic sulfolane extraction in the sulfolane EU to remove the octane gasoline blend stock. In the aromatic extraction/sulfolane extraction process, the NPR initially mixes sulfolane with the petroleum feed stock (naphtha and light distillates). Sulfolane extracts the aromatics from the feedstock. The aromatic-laden sulfolane is then sent to a stripper for aromatic removal before returning to the EU. After the aromatics are removed, the residual feedstock (referred to as "reffinate") is sent to a wash tower to have residual sulfolane removed before it is sent out as product. Reffinate commonly contains residual amounts of sulfolane in varying amounts (Shannon & Wilson 2006). Sulfolane and sulfolane use at NPR are described in further detail below.

2.4.1 Sulfolane

Sulfolane is an industrial solvent used in liquid-liquid and liquid-vapor extraction of compounds such as aromatic hydrocarbons from petroleum. Sulfolane elevates the aromatic hydrocarbon content of some refined fuels (Shannon & Wilson 2001) and also has reportedly been used in fractionalization of wood tars, as a component of hydraulic fluid, in textile finishing, as a curing agent in epoxy resins, and in the electronics and plastics industries (ATSDR 2010; Komex 2001).

The systematic name for sulfolane is tetrahydrothiophene-1,1-dioxide (CAS # 126-33-0). Sulfolane is colorless, heterocyclic, organic molecule containing sulfur. Sulfolane has no odor, and is both chemically and thermally stable. Sulfolane is highly polar due to oxygen atoms bonded to sulfur atoms, making it completely miscible in water, acetone, glycerol, and many oils. Additionally, it is neither very volatile nor highly viscous (Shannon & Wilson 2006). Sulfolane is not well absorbed through human skin; however, it is well absorbed through the oral route (ATSDR 2010).

Because sulfolane is highly soluble and thermally stable, and has a low affinity for sorption, it is mobile and has the potential to migrate to ground water at a velocity that is similar to the seepage rate (Barr 2010). Once in the saturated zone, the migration rate of sulfolane is likely a function of the hydraulic conductivity of the aquifer material, the hydraulic gradient, and the susceptibility of sulfolane to biological attenuation processes (Komex 2001).

2.4.2 Sulfolane Use at Flint Hills NPR

Sulfolane is currently stored in Tank 194 at the NPR. It is used in the Sulfolane EU in the CU #2 processing area (Figure 2-1). The sulfolane extraction process was added to the refinery in 1985, when CU #2 was constructed. Unlike more complex refineries, the NPR does not employ cracking (the use of heat and pressure to break large hydrocarbon molecules into smaller light molecules) (EPA

1995) or other conversion processes to change the molecular structure of the hydrocarbons received in the crude oil. Alternatively, the NPR uses sulfolane in a liquid extraction process to recover high purity aromatics from hydrocarbon mixtures (Shannon & Wilson 2006).

Sulfolane solvent is received at the site via railcar and tanker trucks and is off-loaded to Tank 194. The NPR uses sulfolane sold by Chevron Phillips Chemical Company, L.P., under the brand name Sulfolane W. Sulfolane W is a mixture of 3 percent water, a small amount of monoethylamine, and sulfolane. Sulfolane is delivered from Tank 194 to the Sulfolane EU in the CU #2 processing area via aboveground piping. Sulfolane is used in the EU to extract aromatics in the process of making gasoline from crude stock (Barr 2012).

The sulfolane process is a liquid-liquid extraction process that is completed after the crude undergoes desalting, atmospheric distillation, and vacuum distillation. In this process, crude oil is separated into gas, naphtha, light distillates, gas oil, and reduced crude in the atmospheric distillation units. The naphtha and light distillate are sent to the EU (Figure 2-1) to produce high octane gasoline blend stock (Barr 2012).

As indicated in the EU process flow diagram (Figure 2-3), sulfolane is initially mixed with the naphtha and light distillates in the EU to extract the aromatics. The aromatic-laden sulfolane is sent to an extract stripper, then to the solvent recovery column to remove the aromatics; the sulfolane is recirculated in the EU and reused in the extraction process. After the aromatics are removed, the residual feedstock (raffinate) is sent to a wash tower to remove residual sulfolane (Barr 2012).

Currently, the only fuel produced at the NPR that requires the sulfolane process is gasoline. Sulfolane content in gasoline produced at Flint Hills from 1992 through 2009 is shown in Table 2-1. Data for gasoline produced prior to 1992 are no longer available. The table shows that sulfolane content in gasoline has been reduced since 2004. Military jet fuel (JP4) was produced using naphtha in the sulfolane extraction unit. JP4 production was discontinued in 2005. Sulfolane content data for JP4 are unavailable (Barr 2012).

While gasoline is the only product currently and historically produced at the NPR that requires the sulfolane extraction process, sulfolane may migrate into other NPR products due to incidental “carry over” into that portion of the manufacturing operation through the Flint Hills’ piping system. Fuels that may have contained sulfolane in the past include #1 fuel oil (jet fuel) and #2 fuel oil (diesel fuel). Only gasoline is monitored for sulfolane content, as it is the only fuel produced at Flint Hills with a sulfolane specification. However, as Table 2-1 indicates, since sulfolane content was significantly reduced in 2004 and made even lower in 2005, the percentage of sulfolane in another product produced since 2004 due to carry over would be low (Barr 2010).

2.4.3 Potential Sources of Contamination

Spills onto or into land from refinery operations have occurred several times throughout the NPR's history. These spills have resulted from leaking storage tanks, leaking sumps, overflow of the wastewater handling pond, and certain handling procedures (ADEC 2012). During the late 1970s and 1980s, very large, but unknown, amounts of petroleum product leaked from aboveground bolted storage tanks. These tanks have since been taken out of service. Table 2-2 provides a summary of past spills, including both the product type and the volume released, that have occurred at the plant since 1977 (Barr 2012).

In 1982, MAPCO (the owner at the time) began recovering light non-aqueous phase liquid (LNAPL) from the subsurface. In 1987, monitoring well data indicated that ground water on the refinery was contaminated with petroleum compounds such as benzene, toluene, ethylbenzene, xylenes, trimethylbenzenes, and naphthalene above the Alaska Department of Environmental Conservation (ADEC)'s regulatory maximum contaminant levels for drinking water. In 2001, while conducting site characterization activities, an unknown chemical scattered in site groundwater was found. Further analysis identified it as sulfolane (ADEC 2010). At the time of its detection, sulfolane did not have an established maximum contaminant level (Barr 2012).

Potential sources of contamination include those processes or locations at which sulfolane was used, stored, or transported within the NPR. These include ASTs; ; the process areas, including CUs #1, #2, and #3 and the EU; and the wastewater system, including the wastewater lagoons, sumps, and drain systems. ASTs where sulfolane was thought to be present, or potentially present, include Tanks 194, 192, 195, and 196. These sources and processes are discussed below (Barr 2012).

2.4.3.1 Aboveground Storage Tanks

Petroleum products are stored in ASTs located in the central portion of the site (Figure 2-1). The ASTs are all constructed within bermed and lined containment areas.

In particular, historical facility records indicate leaks in Tanks 508 and 509 (the bolted tanks), as well as in their containment area, indicating that they were potential sources of releases to ground water at the site. Tanks 508 and 509 were 10,000-barrel bolted steel, repurposed military tanks located near the south end of containment area CA5 (Figure 2-1). The containment area around Tanks 508 and 509, although lined, was reported to have leaked due to holes punctured in the liner during construction (Barr 2012).

These tanks were used to store hydrocarbon product until 1986, when they were decommissioned. The tanks were then used to provide extra storage and treatment capacity for wastewater when Lagoon B was full. Wastewater at the NPR has been documented to contain high levels of sulfolane. The wastewater system is discussed in Section 2.4.3.2. Aerial photographs indicate that these tanks were removed sometime between 1993 and 1995. It does not appear that Tanks 508 and 509 would have been material sources of sulfolane to ground water because a majority of the releases from these tanks predated sulfolane use at the site and refinery personnel have indicated that liners may have been installed into the bolted tanks prior to their use in wastewater treatment activities. No information is available regarding the type of liner used, nor integrity testing of the liners (Barr 2012).

2.4.3.2 Wastewater System

The site is currently configured with three lagoons—Lagoons A, B, and C (Figure 2-1). Lagoons A and C are currently in operation for storage and treatment of wastewater. Lagoon B, which was decommissioned in 2006, was the only wastewater lagoon on site between 1977 and 1987. Lagoons A and C were built in October 1987 and September 1989, respectively.

Sulfolane from the EU can enter the wastewater system through general maintenance activities, during turnarounds, or from relief valves that drain into the sumps discussed in Section 2.4.3.3. Historical records reflect that sulfolane has been measured in wastewater at the refinery and has been found and monitored in many portions of the wastewater system. Therefore, releases of wastewater to the subsurface from the lagoons may have included sulfolane (Barr 2012).

Waste Water Storage Tanks

As noted previously, Tanks 508 and 509 (i.e., the Bolted Tanks) were also used for the storage and treatment of wastewater after they were taken out of service for product storage in 1986. Reportedly, the bolted tanks were used when Lagoon B was full and the refinery required storage of additional out-of-spec (e.g., >250 ppm sulfolane, biological oxygen demand/chemical oxygen demand) wastewater before treatment. Liners may have been installed into the bolted tanks prior to their use in wastewater treatment activities. No information is available regarding the type of liner used, nor integrity testing of the liners (Barr 2012).

Wastewater tank 192 was installed during the construction of the refinery in 1977 and was used to collect material, including storm water runoff from the oily water sewer system. Tank 192 separated the hydrocarbon and water fractions, hydrocarbons were returned to the refining process, and wastewater was sent to treatment or vaporization. Wastewater tanks 195 and 196 were constructed in 2003 and are currently used as buffer tanks for potentially out-of-spec wastewater (> 250 ppm sulfolane). Wastewater is placed into Tank 195, then Tank 196. Samples are collected from the tanks as necessary (as they fill) and analyzed for sulfolane. Samples are also collected from Tank 192 generally daily, Monday through Friday. If the Tank 195 and Tank 196 sulfolane concentrations exceed 250 ppm, then wastewater is metered into the system using predetermined pumping rates (based on the measured concentrations) to ensure adequate dilution of the sulfolane prior to flowing to Tank 192. If the concentrations are less than 250 ppm, then the wastewater is placed directly into Tank 192 (Barr 2012).

Historical wastewater records indicate sulfolane in wastewater has been measured at levels exceeding 1,000 ppm. An average daily sulfolane concentration of approximately 2,000 ppm has been calculated using a limited data set (2010 and 2011). Concentrations are believed to have varied significantly as wastewater management practices have improved. General process knowledge indicates that sulfolane-containing wastewater has been introduced to Sump 02/04-2, and historical data indicates the presence of sulfolane in Lagoon B, Sump 908, and Tank 192, and more recently in Tanks 195 and 196 (Barr 2012). Additional discussion of Sump 02/04-2 and 908 follows.

Wastewater Lagoons

Before October 1987, what is now known as Lagoon B was the only lagoon in the wastewater treatment system. Once Lagoon A was constructed in October 1987, Lagoon B received aerated wastewater from Lagoon A through September 1989, when Lagoon C was constructed.

Records for Lagoons A and C indicate both lagoons were constructed as a double-lined system with leak detection. Lagoon A records from 1988, 1991, 1996, and 1997 indicate there were integrity issues with the liner system in this lagoon. Records for Lagoon C indicate there had been liner integrity issues prior to 2000 in this lagoon. The records are unclear as to whether significant releases were associated with the liner integrity issues. General process knowledge and data from Tank 192, which discharges at times to this lagoon, indicates the possibility that sulfolane may have been included in wastewater stored in Lagoons A and C (Barr 2012).

Historical records indicate there have been liner integrity problems with Lagoon B that have resulted in sulfolane releases that have impacted ground water, as indicated by data collected from adjacent ground water monitoring well MW-110. Lagoon B was reported to have been removed from active service and replaced by Lagoon C in September 1989. However, aerial photographs indicate liquid was still present in Lagoon B soon after Lagoon C was introduced to the wastewater treatment system in 1990 and 1991. The wastewater held in Lagoon B was pumped into Lagoon C starting on May 22, 1991, continuing throughout the month (Barr 2012).

Closure operations for Lagoon B began in 1990 but were not completed until July 1991, at which time the liner was removed. After closure operations were completed at Lagoon B in 1991, the liner was replaced and use of the lagoon was reserved for out-of-spec (i.e., >250 ppm sulfolane or biological oxygen demand/chemical oxygen demand) wastewater until the lagoon was emptied in 2006. Records and aerial photographs indicate water resided in Lagoon B throughout much of that time period (Barr 2012).

Records also indicate that holes in the lagoon were initially identified in 1986 and again in 1990 and 1991. When the lagoon was emptied in 2006, additional holes and tears were found in the liner. Historical records indicate high-sulfolane concentration wastewater was stored in Lagoon B prior to 2003, and ground water data collected from MW-110 (located at the northeast corner of Lagoon B) indicate Lagoon B was a historical source of sulfolane to ground water (Barr 2012).

2.4.3.3 Sump and Drain System

The facility's oily water sewer system collects water from the process areas, tank farms, skid runoff, laboratory, truck rack and railcar-loading area catchment basins, the sump and drain system, and the equipment-loading area. Sumps, constructed as part of the original refinery, were made of concrete; however, because containment issues were observed in the concrete sumps, they were lined with steel during the 1984–1986 timeframe. Additional sumps were constructed on an as-needed basis as additional facilities were added to the refinery. Sumps and drains are underground structures at the site, and there is potential for leaks from the sumps and drains to the subsurface under the site (Barr 2012).

In 2009 and 2010, Flint Hills undertook a comprehensive evaluation of the integrity of the oily water sewer system (the sump and drain systems) at the refinery. Integrity issues were identified for five of the 42 refinery sump systems. These five sumps were potential sources of releases to the subsurface. However, three of the five sumps found to have integrity issues would not have come in contact with sulfolane during operation. All of the five sumps were repaired by Flint Hills. Also, the inner shell of Sump 02/04-2, which would have been the recipient of material containing sulfolane, was not found to have integrity issues during this inspection. However, the 2009 and 2010 evaluation of the sump and drain system revealed that a repair of the sump made in 1997 did not provide for a weld which penetrating in the shell. Further, the drain lines from CU #2 into the sump were found to have integrity issues (Barr 2012). .

Evidence of Historical Releases from Sump 02/04-2

Sump 02/04-2 (Figure 2-4) is located between CU #2 and the EU (Figure 2-1) and acts as a collection point for both units, connected to both by a drain piping system. It has been also used to collect residual draindown and wash water during EU turnarounds (maintenance events). Turnarounds for the EU required de-inventorying of process tanks within the unit by transferring sulfolane-containing fluids to tanks or railcars positioned at the south end of the rail spur adjacent to Lagoon B. After the process tanks were de-inventoried, the residual material and the wash water were allowed to gravity-drain to sump 02/04-2. EU turnarounds occurred every year or every other year from 1985 (when the unit was constructed) until 2003, then again in 2006 and 2010 (Barr 2012).

Sump 02/04-2 appears to have been a source of sulfolane to ground water, based on sump and piping integrity records and the ground water chemistry from downgradient monitoring well MW-138. Integrity issues were identified during an inspection on November 3, 1997, that found that the bottom of the sump had corroded through. On November 10, 1997, the operator at the time installed a new steel liner in the sump and coated the sump with polyurethane foam (Barr 2012).

Sump 02/04-2 and piping leading to the sump were inspected in May 2009. The inspection revealed that a gasket for a nozzle in the sump had deteriorated and that no back-weld had been completed during the 1997 repair. Tightness testing was completed on the piping that leads from CU#2 and the EU into the sump. The line from the EU passed the test; however, the drain line leading from CU #2 into Sump 02/04-2 failed the test. The drain leading from CU#2 to Sump 02/04-2 was removed from service and isolated from the sump by installing a blind flange in the sump. Sulfolane has not used in CU#2 (Barr 2012).

Sump 908

Sump 908 is located southwest of the current gallery pond (Figure 2-4) and receives wastewater from the salt drier, which removes water from hydrocarbon products. Wastewater produced from this process has been reported historically to have high sulfolane concentrations (e.g., 35,000 to 55,000ppm in 2000).

Sump 908 was found to have pitting and complete failure in the steel walls, base, and piping to the sump during an inspection in 1997. In response to the findings of the inspection, Sump 908 was lined with steel and coated with a polymer on October 17, 1997.

An inspection report from September 26, 2006, indicates that minimal corrosion was found in the sump. No instances of through corrosion were identified, and no polymer liner was indicated.

A July 6, 2010, inspection report indicates that a polymer coating in the sump had failed. Heavy corrosion and pitting were identified during the visual inspection, which identified pin-size holes in various areas on the floor and shell. The suggested remedy was to recoat and repair the shell and floor of the sump. Soon after the inspection, the shell and the floor were replaced with new plates (Barr 2012).

2.5 Spill Events and Releases

As mentioned above, spills and releases have occurred at the NPR. A spill summary is presented in Table 2-2. Spill records from the NPR do not reflect all of the material historically spilled, as evidenced in reports from the 1980s that indicate the recovery of substantially more product than had been documented as releases. Spill records also do not reflect releases that may have occurred from below-grade structures, particularly including the oily water sewer system and lagoons (Barr 2012).

2.5.1 Volume Released

Ninety-two spills were reported between 1977 and 1987, resulting in more than 160,000 gallons leaked or spilled at the site. However, the same report also stated that 275,000 gallons of product were recovered. Suggesting that considerably more product had been recovered than was reportedly spilled.

A total of 3,096 documented spills have been reviewed from 1977 to 2010. From those records; 2,863 of the spills included volume estimates. The total volume of the documented spills was approximately 281,964 gallons (Barr 2012).

2.5.2 Release Locations

Records reflect spills in numerous locations throughout the site (Table 2-2). These locations include the process areas (CUs #1, #2, #3, and the EU); the area of the lagoons; product storage areas (e.g., tank farms); the railcar-loading rack area; and the current and former truck-loading rack areas (Figure 2-1). Based on Table 2-2, approximately seven releases of pure sulfolane have occurred at the site, totaling 279.008 gallons. Further, approximately 44 releases of wastewater have occurred at the site, totaling 6,727gallons of water potentially containing sulfolane (Barr 2012).

2.6 Previous Investigations

The NPR has been the subject of many investigations and sampling events since the mid-1980s; The discussion of previous investigations provided below focuses only those related to sulfolane contamination, which is the focus of this PA.

2.6.1 Contaminant Characterization Study

In 2001, Shannon & Wilson conducted a Contaminant Characterization Study to fill data gaps identified following an earlier site characterization effort for an ADEC- and EPA-mandated Corrective Measures Study. Information in this section and the following subsections was gathered from the Shannon and Wilson report. This investigation focused on the distributions and types of organic petroleum contaminants potentially present in the soil and ground water at the facility. In an effort to assess the widest possible variety of potential contaminants, sampling was conducted from areas known to be contaminated from past releases as possible. Areas anticipated to be free of contamination were also sampled to assess potential background concentrations of naturally occurring metals and to establish the absence of contamination. Samples were collected in March, May, and August of 2001. Sampling results are discussed below.

In addition to the planned sampling activities, subsurface contamination discovered in areas anticipated to be free of contamination led to additional subsurface investigations and additional ground water analysis. New monitoring wells were placed west of the truck loading area (Figure 2-6) in hopes of successfully delineating the western extent of the ground water benzene plume in that area.

An unknown organic analyte was detected in an otherwise hydrocarbon-free well. This analyte had hydrocarbons in the diesel range. The discovery of the unknown analyte prompted additional water sampling from several existing monitoring wells to help identify it. The analyte was found to be sulfolane. At the time of the discovery, sulfolane did not have a ground water cleanup standard and was not listed in the EPA risk-based concentrations tables.

2.6.1.1 Ground Water Sampling

Ground water samples were collected from 10 monitoring wells (Figure 2-6). Six of these were expected to be hydrocarbon free (based on previous sampling). Four of these were new wells installed in 2001. Each monitoring well contains its own dedicated pump. In general, samples were analyzed for gasoline range organics, diesel range organics (DRO), residual range organics, and benzene toluene, ethylbenzene, and xylenes (BTEX) if they had been previously identified as being free of hydrocarbon contamination. New wells, and wells that had previously exhibited hydrocarbon contamination, were analyzed for volatiles and semivolatile organic compounds as well.

In addition to the 10 samples noted above, following detections of a single DRO analyte from wells historically free of hydrocarbons, verification samples were collected from two additional wells (MW-101 and MW-101A) (Figure 2-6) for DRO analysis and sulfolane analysis by the refinery laboratory. Each of these samples confirmed the unknown DRO was sulfolane.

2.6.1.2 Ground Water Sampling Results

As stated above, an unknown DRO analyte was detected in samples from two monitoring wells on May 10, 2001. Laboratory results indicated that the unknown analyte had a hydrocarbon peak in the C_{12} to C_{13} alkane range. These wells were re-sampled for DRO only on July 26, 2001, with duplicate samples collected at the same time for analysis by the refinery laboratory in order to determine if the unknown hydrocarbon was sulfolane. The unknown analyte was detected in the July samples, and only sulfolane was detected in the samples analyzed by the refinery laboratory. Sulfolane was the unknown eluding analyte in the DRO range.

2.6.2 Site Characterization and Corrective Action Plan

In 2002, Shannon & Wilson submitted a Site Characterization and Corrective Action Plan (SC/CAP) to Williams Alaska Petroleum, Inc. The information in this section and the following subsections was gathered from this 2002 report. This 2002 SC/CAP built on the 2001 Contaminant Characterization Study, presenting information regarding the subsurface hydrogeology and geology at the refinery, historical contaminant concentrations, and preventative measures in place to minimize further soil and ground water contamination. It also included a corrective action plan and a long-term monitoring schedule. However, sulfolane was not included in this report because it was not a regulated substance at the time the report was submitted. The following subsections outline the contents of the SC/CAP.

2.6.2.1 Preventative Measures

The report outlines several measures that have been implemented to minimize the potential for contaminant release to soil and ground water. Recovery wells were installed to remove non-aqueous phase liquid (NAPL) from ground water via air strippers before being discharged to the gallery pond. Effluent from the gallery pond is then discharged to the south gravel pit and then the north gravel pit.

Several observation wells were also installed to aid in the delineation of the NAPL plume. Product and water pumps are checked daily for proper operation. Additionally, a network of monitoring wells were established around the refinery, downgradient from known areas of contamination. These monitoring wells are sampled on a regular basis. The NPR ground water monitoring and remediation program is discussed further in Section 2.6.4.1.

Flint Hills developed an oil spill prevention and contingency plan that included spill prevention training and periodic refresher courses for all workers involved in operations that could lead to a spill. Procedures to minimize the possibility of spills have been established for product transfer operations, such as hard line transfer and readily available emergency shut off buttons. Additionally, dikes and containment basins are inspected and tested annually.

2.6.2.2 Conceptual Site Model

A schematic conceptual site model (CSM) was constructed based on ground water quality data to describe the inferred extent of subsurface benzene contamination (Figures 2-7 and 2-8). This figure represents a cross section through the refinery running roughly parallel to ground water flow. The CSM depicts only three areas in which the largest historic fuel releases have occurred (Crude Unit #1, former bolted tanks, and the area near tanks 510-514). However, many more releases of varying amounts have occurred at the site that are not shown in the CSM.

2.6.2.3 Corrective Action Plan

As part of the corrective action plan, all existing monitoring, observation, and recovery wells were inventoried. Wells were identified and evaluated for their likely future utility in assessing ground water gradient, determining contaminant levels, delineating NAPL extent, and effecting product recovery. Based on the evaluation, recommendations were made as to which wells would remain in service and which would be removed.

Based on the available data, benzene appeared to be the most soluble contaminant of interest. Because of this, it was determined that BTEX compounds are the most appropriate analytes to monitor for and should sufficiently track subsurface movement of dissolved petroleum compounds. It was suggested that sampling for BTEX be conducted monthly (at a maximum) to annually (at a minimum), based on each well's location. Additionally, it was recommended that ground water geochemistry be monitored to assess the contribution of naturally occurring microbial populations to attenuation of hydrocarbon contamination downgradient of the site.

The SC/CAP was approved by the ADEC in January 2006 and included a new requirement that sulfolane would be regulated with a ground water cleanup goal of 350 µg/L at Flint Hills (ADEC 2006; Barr 2010).

2.6.3 Results of Ground Water Monitoring for Sulfolane and Proposed Long-term Sulfolane Ground Water Monitoring Program

In October 2006, Shannon & Wilson reported the results of several months of ground water monitoring at the NPR. Ground water was monitored for sulfolane. The goal of the sampling was to determine whether sulfolane concentrations varied with time or remained stable. Determining this would provide information regarding the source of sulfolane. If concentrations showed a steady decrease, it could be reasoned that a sulfolane release was a discrete event. However, if concentrations were determined to be steady, it could be reasoned that sulfolane was being released to ground water at the same rate it was leaching from the site (Shannon & Wilson 2006).

In April 2006, ground water samples collected from eight wells located in the northeast portion of the refinery and three wells located in the southern and central portions of the refinery indicated that sulfolane concentrations exceeded ADEC cleanup levels. Samples were also collected from wells located in the central, western, and northwestern portion of the refinery, but concentrations were below ADEC cleanup levels. Additionally, samples from wells located in the northeast and eastern portions of the refinery did not contain sulfolane above practical quantitation limits. Based on the April 2006 sampling data, the sulfolane assessment was refocused on the area downgradient of Crude Unit #2 (Shannon & Wilson 2006).

Additional sampling in May, June, and July of 2006 indicated that sulfolane concentrations remained relatively constant over the sampling period. Based on the sampling data, Shannon & Wilson concluded that sulfolane concentrations were due to chronic contributions from a continuous source, rather than the result of an acute release. The highest concentrations of sulfolane were located in wells near the Crude Unit #2 and rail car loading areas (Shannon & Wilson 2006).

2.6.4 Site Characterization Work Plan

In 2010, Flint Hills prepared a Site Characterization Work Plan (SCWP) to provide a description of tasks to be completed to update the CSM for the site based on the March 3, 2010, request by ADEC. Additionally, as requested in the March 3, 2010, letter from the ADEC, Flint Hills submitted an Interim Removal Action Plan (IRAP) as a concurrent submittal to the SCWP. The IRAP is discussed further in Section 2.6.5.

ADEC requested that Flint Hills prepare an SCWP after Flint Hills reported that they had learned of a sulfolane plume that extended outside of the facility property boundaries. In October 2009, a sampling event conducted by Flint Hills indicated that sulfolane was present in both private and public drinking water wells near the refinery. Following notification to the ADEC, Flint Hills immediately began simultaneous efforts to delineate the extent of the sulfolane plume, test the drinking water supplies of those living in the vicinity of NPR, and offer an alternative drinking water supplies to those with impacted wells.

As stated above, the June 2002 SC/CAP prepared by Shannon &Wilson did not include sulfolane. The ADEC approved the SC/CAP in January 2006 (ADEC

2006) and included a new requirement that sulfolane would be regulated with a ground water cleanup goal of 350 µg/L at the NPR. In a letter to Flint Hills dated March 3, 2010, the ADEC indicated that, based on new information related to sulfolane, the January 2002 SC/CAP was no longer sufficiently protective, and a new interim cleanup standard of 25 µg/L based off of the recommended public health action level developed by the Agency for Toxic Substances and Disease Registry (ATSDR) was being considered. In this letter, the ADEC directed Flint Hills to prepare a SCWP to address these new conditions. The new cleanup level of 25 µg/L imposed by ADEC was based on the February 2010 findings of a review performed by the Alaska Department of Health and Social Services and ATSDR to determine the potential risk posed to humans from exposure to sulfolane.

The SCWP identifies data gaps in the understanding of environmental conditions at the NPR and proposes tasks to fill those data gaps and update the CSM. Specific objectives of the tasks proposed in the SCWP include the following:

- Update the site Contaminants of Potential Concern.
- Identify the historic source(s) of sulfolane and the potential for ongoing releases.
- Improve understanding of the on-site physical setting the off-site physical setting, including the geology, hydrogeology, permafrost, and ground water geochemistry.
- Characterize the nature and extent of soil impacts at the NPR, once the Contaminants of Potential Concern are updated, the spill locations are understood, and sulfolane use is understood.
- Characterize the nature and occurrence of LNAPL at the NPR.
- Improve understanding of petroleum constituents in ground water at the NPR.
- Complete the delineation of sulfolane in ground water downgradient of the NPR.
- Evaluate the potential for natural attenuation of sulfolane in ground water downgradient of NPR.
- Characterize water quality with respect to sulfolane in the north and south gravel pits at the NPR.
- Update the CSM.
- Evaluate the migration of sulfolane in ground water through analytical modeling.
- Monitor the effectiveness of the corrective measures proposed in the IRAP.

2.6.4.1 Ground Watering Monitoring Program

The SCWP describes the extensive network of wells that have been installed at the NPR in response to releases that have impacted ground water at the refinery. The 2010 on-site and off-site ground water monitoring network at Flint Hills includes monitoring wells, observation wells, and recovery wells (Figures 2-9 and 2-10). Monitoring wells are used primarily for ground water quality monitoring. Observation wells are primarily used to monitor for LNAPL. Recovery wells are used (or were used in the past) to recover LNAPL and impacted ground water.

Prior to October 2009, 43 monitoring wells were present at the NPR. In October 2009, Flint Hills initiated an effort to delineate sulfolane in ground water downgradient of the NPR, and also in deeper portions of the aquifer beneath NPR. To date, 40 of these plume delineation wells have been installed (Figure 2-9).

Twenty-eight observation wells are located on site at NPR (Figure 2-9). Observation wells appear to be screened across or just below the water table. Thirty recovery wells also are located on site at NPR. These wells are used to recover LNAPL and impacted ground water. The recovery wells appear to be constructed across the water table.

The current ground water monitoring program consists of ground water elevation, LNAPL, and ground water quality monitoring. It also includes monitoring of the active remediation system.

On-site ground water samples are currently collected and analyzed for sulfolane from 32 monitoring wells, four observation wells, and one recovery well (Figure 2-9). At the new delineation wells (Figure 2-10), ground water samples are currently collected and analyzed monthly for sulfolane.

2.6.4.2 Contaminant Distribution

The SCWP indicates that at some locations, on-site free-phase petroleum product exists on the water table as LNAPL. Measurements of LNAPL are conducted quarterly. LNAPL thicknesses range from sheen up to 1.8 feet in wells located near CU #1, CU #2, and the former truck loading rack (Figure 2-1).

As discussed earlier, ground water is monitored for and sulfolane. Sulfolane has been detected in samples of ground water collected at the NPR, as well as in monitoring wells and residential wells located downgradient (northwest) of the NPR (Figure 2-11). Additionally, intermittent detections of sulfolane have been reported at levels below practical quantitation limits in the city of North Pole formerly used municipal wells, which are located downgradient of the site.

Figures 2-12 and 2-13 indicate that the sulfolane plume is present at the water table beneath the tank farms and Crude Units #1 and #2 and has migrated from the NPR in a north-northwesterly (downgradient) direction.

Figure 2-14 shows data from the monitoring wells installed at a depth of 15 to 55 feet below the water table. Figure 2-15 shows data from the monitoring wells installed thus far at 55 to 90 feet below the water table. The extent of the plume exceeding the ADEC set 25 μg/L cleanup level has not been defined. Figure 2-16 shows data from the three monitoring wells installed between 90 and 160 feet below the water table. Add the time of SCWP development, sulfolane had not been detected in samples collected from these wells.

2.6.4.3 Contaminants of Potential Concern and Proposed Future Monitoring

The SCWP indicated that BTEX would be used as the primary indicator of petroleum impacts on site. Data indicate that the benzene plume does not extend beyond a depth of 25 feet below the water table; therefore, the proposed BTEX monitoring network in the SCWP consisted of wells completed within 25 feet of the water table. No new wells were considered to be needed for future monitoring of BTEX. Wells beyond the leading edge of the plume would be sampled semiannually to provide data to demonstrate a lack of migration of the BTEX plume. Wells located within the plume would be sampled semiannually to track the attenuation of the plume. Wells located east and south (upgradient) of the plume would be sampled annually.

Sulfolane was first detected in two monitoring wells that had shown no petroleum-related contamination in 2001. Since the first detection of sulfolane in 2001, sulfolane has been detected at the water table and also at depth within the aquifer at the NPR and off site. Monitoring well networks were proposed in the SCWP that would serve to define and track sulfolane at different depth intervals within the aquifer.

On-site well sampling frequency was proposed as follows:

- Quarterly at observation wells located closest to the four active recovery wells for the purpose of monitoring the effectiveness of these wells;
- Quarterly at wells located downgradient of the active recovery wells to monitor changes in the plume during corrective action implementation;
- Quarterly at wells located along the plume flanks between the active remediation areas and the property boundaries to monitor for changes in the plume extent;
- Semiannually at all other wells within the plume to monitor plume attenuation; and
- Annually at the upgradient location.

An additional four wells were proposed in the SCWP for future sulfolane monitoring off site near the water table (Figure 2-17). No additional wells were expected to be needed for on-site monitoring of sulfolane. Nine additional wells were proposed for future sulfolane monitoring in the aquifer from 15 to 55 feet below the water table (Figure 2-18). Seven additional wells were proposed for future sulfolane monitoring in the aquifer from 55 to 90 feet below the water table (Figure 2-19).

2.6.5 Interim Removal Action Plan

In 2010, Flint Hills submitted an IRAP to the ADEC, as requested in its March 3, 2010, letter. The IRAP was submitted concurrently with the SCWP, which is discussed above in Section 2.6.4. The purpose of the IRAP was to evaluate the existing ground water monitoring system and present recommendations for optimizing it to address the LNAPL and sulfolane-contaminated ground water at the NPR. Information in this section and following subsections was gathered from the IRAP.

2.6.5.1 Existing Remediation System Evaluation

LNAPL Recovery

Currently, a free-phase product recovery system is operated at six locations. These systems include a pneumatic floating product-only (hydrophobic) skimmer pump, passive product recovery canisters, and product-only (hydrophobic) recovery pump. Additionally, product recovery is completed by vacuum truck in some locations. Following the IRAP evaluation, additional floating skimmer pumps were recommended to allow for continual product recovery.

Ground Water Capture

The current ground water recovery system includes four active recovery wells. The remediation system evaluation concluded that additional recovery wells should be installed and that all wells should operate at maximum capacity. An increase in operation would create a capture zone that would encompass the horizontal extent of the shallow sulfolane plume and also maintain/increase capture of the benzene plume.

Ground Water Treatment

The four recovery wells discharge to a common manifold where the water they recover passes through a filter unit to remove suspended solids and a coalescer to remove LNAPL. The discharged coalescer water is routed to four air strippers, which operate in parallel to remove volatile organic compounds associated with historic petroleum releases. Typically, only two air strippers operate while the others undergo maintenance. Each air stripper has a capacity of 300 gallons per minute. Discharge form the air strippers is routed to the gallery pond for collection. The gallery pond is lined and the water level maintained by discharge pumps that pump to the south gravel pit. Water accumulates in the south gravel pit and flows to the north gravel pit, where it infiltrates the ground surface and reenters the aquifer.

In January 2010, Flint Hills began monthly sampling to measure sulfolane removal across the air strippers and gallery pond. Although sulfolane has a low volatility and is generally not amenable to vapor pressure treatment (air stripping), some sulfolane removal has been consistently measured across the air strippers and gallery pond. An average of 52% of sulfolane entering the treatment system is removed. Figure 2-20 presents the layout of the ground water remediation system.

Ground Water Treatment Pilot Study

A granular activated carbon (GAC) filtration system will be added to the ground water treatment system and operated as a pilot study to evaluate its effectiveness in removing sulfolane from recovered ground water. The GAC will be added after the gallery pond to treat water before it enters the south gravel pit. A total of four GAC vessels, each containing 10,000 pounds of GAC, will be installed.

Flint Hills has reported that based on bench-scale testing, the GAC has shown "proof of concept" for sulfolane removal.

2.6.6 Monthly Ground Water Remediation Status Reports

Flint Hills submits monthly ground water remediation status reports to the ADEC, providing updates on its ground water remediation program. The most current available status report is dated December 2009 (Flint Hills 2009). However, the Revised Site Characterization Report (discussed below) indicates that from 1986 through the end of 2011, over 391,000 gallons of LNAPL have been recovered at the NPR (Barr 2012).

2.6.7 Revised Site Characterization Report

Flint Hills prepared a revised Site Characterization Report to describe site characterization tasks that have been completed thus far and the results of those tasks. The tasks were proposed and described in the SCWP (Section 2.6.4) as requested by the ADEC. Data gathered during the site characterization are being used to complete a Human Health Risk Assessment (HHRA). The HHRA estimates the nature and probability of adverse health effects in humans who may be exposed to chemicals associated with the NPR. Information presented in this section was gathered from the Revised Site Characterization Report (Barr 2012). Key site characterization results are discussed below.

2.6.7.1 Determination of Potential Sources of Contamination

As presented above, potential sources of contamination include the areas in which sulfolane may have been present. These areas are product storage tanks;; the process areas; and the wastewater system, including the wastewater lagoons, sumps, and drain systems.

Based on a review of historical documents, the primary contributors to sulfolane impacts to ground water are likely the result of subsurface wastewater releases from sump 02/04-2, sump 908, and Lagoon B. Contributions of sulfolane to the environment from discrete surface spills, including spilled fuels, appear less significant than the subsurface wastewater releases. Analysis of LNAPL samples collected from on-site wells supports this hypothesis, as sulfolane has not been detected in any of the LNAPL samples collected from wells located near the crude units, the tank farm areas, or the former truck-loading rack (Figure 2-1) (Barr 2012).

2.6.7.2. Updated Sulfolane Monitoring

Analyses of ground water samples for sulfolane are conducted at monitoring wells completed at multiple depths within the supra-permafrost aquifer. Information for this section was gathered from the March 2012 *Revised Site Characterization Report.* Sulfolane monitoring network samples vertical zones with respect to the water table as follows:

- Water table wells,
- Wells screened 10 to 55 feet below the water table (BWT),
- Wells screened 55 to 90 feet BWT, and

- Wells screened 90 to 160 feet BWT.

Recorded depths were determined relative to the water table rather than the ground surface since the ground surface is not flat. Further, recording depths were not determined with respect to mean sea level since the water table drops nearly 20 feet from the southeast to northwest across the study area.

The sulfolane monitoring network was been expanded to fill data needs, using both new monitoring wells and existing wells that were previously not used for sulfolane monitoring. The new monitoring wells were installed in six phases and are described below.

Phase 1
The primary goal during installation of the Phase 1 wells was to define the downgradient edge of the sulfolane plume. Phase 1 also included wells installed to define the edge of the plume at depth. Wells were installed moving northwest (downgradient) from the NPR in a step-wise approach, with successive bands of monitoring wells installed following receipt of sulfolane results from previously installed wells. Final well positions were influenced by utility locations and access issues, both in the physical sense (e.g., could a well location be reasonably accessed by sampling technicians? Did permafrost prevent the use of the location?) and with consideration of property ownership (i.e., was the desired well location on public property).

Phase 2
Additional sulfolane delineation wells were installed during Phase 2, which occurred from September 9 to November 24, 2010. These consisted of 17 on-site and 17 off-site wells. As was the case during Phase 1, wells were installed to address data needs for understanding the plume at the water table, and deeper wells were installed to further define both the horizontal and vertical extent of the plume below the water table.

Phase 3
Phase 3 of the well installation effort was conducted from August 12 through September 1, 2011, and was designed to fill vertical and horizontal gaps in the well network. Seventeen wells were installed both on and off site, some to the top of permafrost. Well nests were also installed to fill horizontal gaps between previously installed wells. Well nests consist of three monitoring wells installed in close proximity to one another to allow evaluation of vertical horizons between various portions of the aquifer. Approximate screened intervals of the wells are 5 to 20 feet below ground surface (bgs), 50 to 60 feet bgs), and 90 to 100 feet bgs. These were installed adjacent to the Tanana River.

Phase 4
Phase 4 of the well installation effort continued filling vertical gaps in the network, focusing on installing wells along the centerline and northwest edge of the sulfolane plume, and attempting to delineate permafrost in the area. Nine wells

were installed at existing well locations both on and off site from September 26 through October 12, 2011, with the goal of setting the bottom of the wells at the top of permafrost or 150 feet bgs (approximately 140 to 145 feet BWT), whichever was encountered first.

Phase 5

Phase 5 entailed installing six well nests northwest of the truck-loading area on the refinery property, along a transect perpendicular to the long axis of the sulfolane plume. The purpose of these wells is to assess the vertical distribution of sulfolane from the water table to permafrost or 150 feet bgs (approximately 140 to 145 feet BWT), whichever was encountered first. Eighteen nested wells, plus six additional wells, were installed at the site from early October through early November 2011.

Phase 6

Phase 6 involved installing wells on NPR property to identify the depth of permafrost at seven on-site locations.

2.6.7.3 Fourth Quarter 2011 Ground Water Monitoring

As presented, numerous wells have been installed on site and off site to delineate the sulfolane plume both horizontally and vertically. The area of impact extends approximately 3 miles downgradient from the NPR. On site, the impact is approximately 1,250 feet wide; however, it widens to approximately 11,000 feet off site. On site, sulfolane has been detected at a depth of 80 feet. Off site, sulfolane has been detected in ground water generally at shallow depths and at the top of the permafrost at some locations. There are also a few sub-permafrost private wells that have been impacted by sulfolane. Based on the work that has been completed, Barr believes that "the nature of contamination below the permafrost is a recognized data need that will be further investigated" (Barr 2012).

Since dissolved-phase sulfolane has been detected at various depths in the aquifer, the Flint Hills refinery monitors the ground water from four separate zones within the aquifer: at the water table, 10 to 55 feet BWT, 55 to 90 feet BWT, and 90 to 160 feet BWT. The current Flint Hills sulfolane monitoring well network is presented in Figure 2-21. Table 2-3 presents on- and off-site well construction information. For the purposes of this PA, only the most recent (fourth quarter 2011) ground water monitoring data will be discussed. Table 2-4 presents Fourth Quarter sulfolane analytical results.

Samples were collected from 54 on-site monitoring wells, 14 on-site observation wells, and 72 off-site monitoring wells and were submitted for sulfolane analysis using the isotope dilution method during the fourth quarter of 2011. Wells sampled during this quarter included all monitored zones within the aquifer.

Water Table Wells

Sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from 14 on-site monitoring wells screened at the water table, with results ranging from 28.2 μg/L (MW-116) to 1,150 μg/L (MW-110). Additionally, sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from eight observation wells, with results ranging from 112 μg/L (O-4) to 10,400 μg/L (O-1). Sulfolane concentrations in samples collected from wells O-3, O-12, and MW-116 were flagged by the laboratory as estimated. The maximum sulfolane concentration detected was in observation well O-1, which is located downgradient of CU #2. Figure 2-22 presents sulfolane concentrations at the water table and an estimated 10 μg/L isopleths (Barr 2012).

Sulfolane also was detected above the interim cleanup goal of 25 μg/L in samples collected from 12 off-site monitoring wells screened at the water table. Concentrations ranged from 27.2 μg/L (MW-159) to 151 μg/L (MW-161A, duplicate sample). Sulfolane concentrations in samples collected at wells MW-167A, MW-168, MW-169A, MW-185A, MW-187 and MW-193A were flagged by the laboratory as estimated. The extent of the sulfolane plume in this interval, presented on Figure 2-22, is shown as an isopleth of 10 μg/L (Barr 2012).

10 to 55 Feet BWT

Sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from six on-site wells screened in the 10 to 55 feet BWT monitoring zone, with results ranging from 35.6 μg/L (MW-101) to 284 μg/L (MW-148B). The sulfolane concentration in the sample collected from MW-179B was flagged by the laboratory as estimated. The maximum sulfolane concentration detected at this interval was observed in the sample collected from well MW-148B, which is located at the northern site boundary (Barr 2012).

Sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from 18 off-site wells screened in the 10 to 55 feet BWT zone, with results ranging from 33.3 μg/L (MW-153B) to 316 μg/L (MW-161B). Sulfolane concentrations in samples collected from wells MW-167B and MW-193B were flagged by the laboratory as estimated. The extent of the sulfolane plume for this interval is presented on Figure 2-23 as an isopleth of 10 μg/L (Barr 2012).

55 to 90 Feet BWT

Sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from on-site wells MW-154A (33.1 μg/L) and MW-154B (35.1 μg/L) screened in the 55 to 90 feet BWT. Wells MW-154A and MW-154B are located west of the rail lines in the northern portion of the site (Barr 2012).

Additionally, sulfolane was detected above the interim cleanup goal of 25 μg/L in samples collected from off-site wells MW-159C (106 μg/L) and MW-160B (118 μg/L), which are also screened in the 55 to 90 feet BWT. The extent of the sulfolane plume for this interval is presented on Figure 2-24 as an isopleth of 10 μg/L (Barr 2012).

90 to 160 Feet BWT

Sulfolane was not detected above the interim cleanup goal of 25 µg/L in samples collected from any on- or off-site ground water sample screened in the 90 to 160 feet BWT zone during the fourth quarter 2011 sampling. A detectable concentration of sulfolane in the sample collected from MW-185C was flagged by the laboratory as estimated. Sulfolane analytical results are presented on Figure 2-25 (Barr 2012).

Private Wells

Sampling of private wells has been ongoing from November 11, 2009 through December 31, 2011. Ground water samples from 518 private wells have been collected and analyzed for sulfolane. Samples collected through May 11, 2011, were analyzed for sulfolane by EPA Method 8270D. Subsequent samples were analyzed using the isotope dilution method. The results are shown on Figures 2-26 and 2-27, regardless of well depth and sampling date. Table 2-5 presents well construction information for private wells (Barr 2012). Screen intervals for private wells were assumed to be relatively discrete and consistent within ground water zones

During the fourth quarter of 2011, sulfolane concentrations detected in samples from private wells ranged from 13.1 to 93.1 µg/L. Concentrations of sulfolane were not detected above the laboratory limit of quantitation in 110 samples. Seven additional sample results were flagged by the laboratory as estimated concentrations below the laboratory limit of quantitation.

Figure 2-28 shows results for private and monitoring wells installed 10 to 55 feet BWT. The estimated extent of the plume is similar to that shown on Figure 2-23. The 10 µg/L isopleth has been extended north in the vicinity of the intersection of Badger Road and Peridot Street around a few wells with concentrations less than 10 µg/L, in order to include a group of private wells with concentrations that exceed 10 µg/L.

Results for private and monitoring wells installed 55 to 90 feet BWT are shown on Figure 2-29. The sulfolane plume extends off site at this depth, but shallow permafrost may be limiting its lateral migration. Sulfolane was reported in several private wells at this depth; all are located along Badger Road north of Richardson Highway.

Results from wells installed 90 to 160 feet BWT are shown on Figure 2-30. Based on available construction information, the private well samples with sulfolane appear to be installed below permafrost. Sulfolane was reported as estimated concentrations in two samples from monitoring wells screened in this zone, both of which are installed above permafrost.

Figure 2-31 shows the results for private wells installed at depths greater than 160 feet BWT. Based on available construction information, these wells appear to be installed in the subpermafrost aquifer; no monitoring wells are installed at this depth. At this time, the mechanism by which sulfolane entered these wells is not understood.

Statistical analysis of sulfolane data conducted by Flint Hills indicates decreasing or probably decreasing trends at 24 locations, and stable concentrations at 11 locations. Wells exhibiting decreasing or stable concentrations include most of the water table wells and most of the wells screened in the 10 to 55 feet BWT. Increasing trends were indicated at six locations within 10 feet of the water table: MW-142, MW-161A, MW-166A, and MW-187 (Figure 2-21), and MW-153B, and MW167B (Figure 2-22). Further evaluation of the MW-142 data indicates fluctuating concentrations are possibly related to ground water elevation changes. Sulfolane concentrations in MW-153B appear to indicate an increase; however, this data set is characterized by periods with no detectable analyte interspersed with measurable concentrations (Barr 2012).

3 Migration/Exposure Pathways

The following sections describe the migration/exposure pathways and potential targets within the site's range of influence (Figures 3-1 and Figure 3-2).

3.1 Ground Water Migration Pathway

The target distance limit (TDL) for the ground water migration pathway is a 4-mile radius that extends from the sources at the site. Figure 3-1 depicts the ground water 4-mile TDL.

3.1.1 Geologic Setting

The NPR is located just outside the city of North Pole, east of the center of the state, approximately 13 miles east of Fairbanks, Alaska.

North Pole itself lies on the north side of the westward flowing Tanana River, approximately 75 miles north of the Alaska Range. The Chena River is a small tributary of the Tanana River, flowing westward approximately 5 miles north of the city. North Pole lies at the base of the Tanana River Valley, a relatively flat-lying alluvial plain, at approximate elevation of 490 feet above sea level. Relief on the valley floor is slight; what little relief is present is caused by abandoned meander scars, small swamps or lakes, or the presence of streams. The Tanana River has a drainage area of 20,000 square miles.

Both the Fairbanks and North Pole areas were not glaciated during the Pleistocene time, although glaciations occurred on a large scale in the Alaska Range to the south and in the Brooks Range to the North. As a result of these glaciations, streams flowing north from the Alaska Range and south from the Brooks Range were heavily loaded with rock and sediment, causing the Tanana River valley to aggrade (Cederstrom 1963).

3.1.2 Geologic Formations

Five notable geologic formations are present in the vicinity of Fairbanks and North Pole. These include (from oldest to youngest) metamorphosed sedimentary and igneous rocks, the older creek gravels, silt, and the sands and gravels on the valley floor. Each formation is discussed below.

3.1.2.1 Bed Rock

Bedrock in the area consists of metamorphosed sedimentary rocks and metamorphosed igneous rocks. The name Birch Creek schist, used in several areas in central Alaska, is applied in the Yukon-Tanana region to all the older Precambrian metamorphosed sedimentary rocks. These consist of quartzite, quartzite schist, quartz-mica schist, mica schist, feldspathic and chloritic schist, and minor portions of carbonaceous and calcareous schist and crystalline limestone. The most common schist appears to be quartzite and quartz-mica schist (Cederstrom 1963).

Associated with the metamorphosed sedimentary rocks above are metamorphic rocks of igneous origin. These include granitic and dioritic gneiss, amphibolite, and several types of schist. Additionally, younger igneous and sedimentary rocks are present in a few small areas. These include granite and quartz diorite of Mesozoic age, sandstone and conglomerate of Tertiary age, and Basalt of Tertiary or Quaternary age.

Bedrock is exposed in very few places, even in areas of higher relief near Fairbanks. In the areas of high relief, bedrock is likely near the surface but is thinly covered by weathered material, moss, or younger alluvial deposits. Depth to bedrock in the flats of the Tanana Valley near the site are not known; however, it is estimated to be 400 to 600 feet (Barr 2010; Cederstrom 1963).

3.1.2.2 Buried Alluvium of Upland Valleys

Alluvium lying on top of bedrock in the valleys in the hills north of Fairbanks has considerable hydrologic significance. The deposits have been found by drilling test wells in several valleys, and they are likely to underlie other locations as well. The alluvium is likely related to coarse gravel deposits that have been worked for their gold content in the larger valleys near Fairbanks (Cederstrom 1963). This unit is not hydrogeologically significant in the North Pole area.

3.1.2.3 Silt and "Muck"

A layer of silt of varying thickness overlies the buried alluvium in the upland valleys and elsewhere in the Tanana River Valley. In general, the silt is tan in color and contains some degree of organic material. However, where organic material is high and the silt wet, the color is black. Miners often referred to the black wet silt as "muck"; however, this term is loosely applied to all dark colored silts. Tan silt contains little organic material compared to the black "muck." The maximum known thickness of this unit is 313 feet. The origin of this unit is unknown, though several hypothesis have been suggested. Origins of the silt range from eolian to degradation of country rock, fluvial, and lacustrine; however, a general consensus as to the origin has not been reached (Cederstrom 1963).

3.1.2.4 Sands and Gravels of the Tanana River

The sand and gravel deposits filling the Tanana Valley are a complex system of alternating lenses of sand, gravel, and silt. The total depth of the formation near the site is not known; however, an injection well drilled to 450 feet bgs on property owned by the Golden Valley Electric Association, which is located adjacent to the site, did not encounter bedrock (Barr 2010).

Up to 2 feet of organic soils are present in the undeveloped areas of the site (Barr 2010). Under these organic soils, deposits consist of every gradation and combination of fine and coarse material. No lens appears to be more than 15 or 20 feet thick, and most of the lenses are thinner. No bed can be traced in the subsurface for any great distance, and marker beds of any kind are unknown. The heterogeneity of the formation is its outstanding characteristic (Cederstrom 1963). Silty soils are thought to have been deposited in sloughs and meander-cutoff channels. Due to the braided nature of the Tanana River, it is likely that discontinuous silty deposits are scattered throughout the formation (Barr 2010).

3.1.2.5 Permafrost

The ground near Fairbanks and North Pole has been frozen to a considerable depth in Pleistocene and recent time. Perennially frozen ground is not ordinarily continuous over wide areas on the valley floor. Thick masses of frozen ground generally thin laterally, either gradually or abruptly, primarily where a stream or the flow path of a former stream is approached.

The maximum depth of permafrost, as determined from domestic well logs near North Pole, is 90 to 230 feet bgs (Barr 2010). Permafrost near the southern edge of Fairbanks is reported to reach a maximum depth of 225 feet (Cederstrom 1963). Permafrost has been encountered at Flint Hills during refinery construction and installation of monitoring wells. During construction of the truck loading ramp, permafrost was detected from ground surface to 15 feet bgs. At a location southeast of the truck loading ramp, permafrost was detected from ground surface to 19 feet bgs. During the installation of three monitoring wells, permafrost was encountered from ground surface to 52.5 feet bgs (MW-102), 9 to 57.5 feet bgs (MW-104), and 21 to 42 feet bgs (MW-120) (Shannon & Wilson 2002).

Permafrost may be a primary factor in the construction of wells in the area. In areas where permafrost is present, shallow ground water may or may not be available above the permafrost. Where shallow water is not available or is considered unsatisfactory, it is necessary to drill through the permafrost to unfrozen ground water (Cederstrom 1963). Additionally, permafrost can act as a confining layer, limiting the flow for ground water (Glass 1996).

3.1.3 Aquifer System

Ground water exists in varying quantities in each geologic formation discussed above. For the purposes of this PA, only aquifer units located within the 4-mile TDL will be discussed in this section.

3.1.3.1 Sand and Gravel of the Tanana River Valley

The sand and gravel of the Tanana River Valley comprise an alluvial aquifer of almost limitless capacity. Alluvium filling the Tanana River Valley is highly transmissive (Glass1996), though discontinuous, as is typical of a braided stream system. Ground water is typically located within a few feet of the surface, though depth to ground water can fluctuate as much as 9 feet due to seasonal variations. In general, ground water is unconfined. The maximum thickness of the valley fill is not known, but is estimated to be as deep as 400 to 500 feet (Shannon & Wilson 2002). Valley fill has been recorded at depths greater than 350 feet near

Fairbanks (Cederstrom 1963) and 616 feet bgs near Moose Creek Dam, located approximately 6 miles northeast of the site (Glass 1996).

Additionally, zones of discontinuous permafrost are present within the alluvium. These zones of permafrost may inhibit ground water recharge locally, but they have no effect on total recharge. Permafrost does pose challenges to construction of domestic wells. Most wells are drilled to the first unfrozen gravelly bed beneath the frozen ground. Typically, domestic wells are completed from 17 to 40 feet bgs. Wells that are completed through permafrost are typically pressurized to maintain water levels below the permafrost. Pressurization helps to keep ground water below the permafrost and prevent the water from freezing in the well (Barr 2010).

3.1.3.2 Hydraulic Properties

Horizontal hydraulic conductivity of the sand and gravel filling the Tanana River valley range from 14 feet per day (based on laboratory tests) to 100 and 1,000 feet per day (based on field tests) (Shannon & Wilson 2002). Additionally, in 1998, Nakanishi reports horizontal hydraulic conductivities ranging from 15 to 2,400 feet per day. Laboratory tests indicate that the horizontal hydraulic conductivity of silt in the Tanana River valley ranges from 0.0027 to 0.037 feet per day (Shannon & Wilson 2002). Little information exists about the vertical hydraulic conductivity of the alluvium filling the Tanana River Valley; however, it is generally less than the horizontal hydraulic conductivity in alluvial aquifers. Layered heterogeneity of the alluvial deposits results in considerable differences in hydraulic conductivity in different directions. Because of the shifting positions of river channels and changing depositional velocities, river deposits have a textural variability that causes heterogeneous distribution of hydraulic properties (Nakanishi 1998)

3.1.3.3 Ground Water Flow

The most recent ground water elevation data obtained indicate that the ground gradient near the refinery is about 5.5 feet per mile (i.e., 0.001 feet per foot) with a general northwesterly flow (Shannon & Wilson 2002). However, subsurface heterogeneity of the valley fill likely causes small-scale variations in ground water flow. Disregarding subsurface anomalies such as permafrost, areas of high density silt, and small-scale variations in gradient, the average ground water velocity near the site has been estimated to be 1.3 feet per day (Shannon & Wilson 2002).

Beyond the area of influence of the site's ground water recovery system, ground water discharges from the Tanana River to the Chena River.

3.1.4 Drinking Water Targets

Ground water within the 4-mile TDL is used for drinking. Approximately 6,309 people use ground water within the 4-mile TDL. The ground water drinking water population by distance ring is presented in Table 3-1.

3.1.4.1 Current Municipal Wells

The City of North Pole municipal drinking water system consists of two permanent wells (Wells No. 3 and 4), located approximately 1 mile east of Flint Hills (Trissel 2012). The City operates one well at a time, though each well is regularly maintained and used. Water from the wells is pumped to a water treatment plant, where it is treated and then distributed. The system serves approximately 550 connections (Trissel 2010, 2012). Based the most current census data, the average house hold size in the Fairbanks North Star Borough is 2.68 people (DOC 2001). Given this average, it is estimated that approximately 1,474 people (550 connections x 2.68 people per household = 1,474 people) are served by the North Pole municipal water system. Additionally, because no potable water source exists at the site, Flint Hills is supplied with potable water by the City of North Pole (Barr 2010, 2012). Approximately 250 to 500 employees work at the NPR who are supplied with drinking water from the City, as well as 2,422 students and teachers within the 4-mile TDL (NCES 2010). A total of 4,396 people are supplied drinking water from the City.

As described above, the City operates two wells. The two wells currently in operation were drilled by Flint Hills to replace wells in which sulfolane had been detected. Both new wells were brought on line in April of 2011. Each well is operated separately for a period of one month and is operated by an automated system. Further, each well was sampled monthly after being brought on line. After a year of sampling and no sulfolane detections, sampling has been reduced to quarterly (Trissel 2012).

3.1.4.2 Former Municipal Wells

Prior the current wells, the City operated two wells, Well No.1, and Well No.2. Typically, Well No. 1 was used in the winter and Well No. 2 was used in the summer. However, because sulfolane concentrations were higher in Well 2, the city opted to use Well No. 1 year-round. Well No. 1 was sampled three times a month, and Well No. 2 only once a month. Sample results from Well No.1 sulfolane concentrations from range non-detect to 5.8 µg/L for raw water and non-detect to 10.0 µg/L for water entering the distribution system, well below the ATSDR recommended public health action level of of 20 µg/L. Sample results from Well No.2 sulfolane concentrations range from non-detect to 7.1 µg/L for raw water and non-detect for water entering the distribution system (Erben 2010). Tests of raw water from both of the City's former wells show low traces of sulfolane; however, the City's water treatment system removed the sulfolane before water reached consumers. The details regarding the operation of the City's water treatment system were not determined for this PA; however, it is known that the treatment system was not designed to remove sulfolane.

Neither of the former wells have been decommissioned; however, neither are currently being used to supply water (Trissel 2012).

3.1.4.3 Domestic Wells

Domestic drinking water well logs within the TDL are maintained by the Alaska Department of Natural Resources. A search of the Alaska Department of Natural Resources well log tracking system (WELTS) revealed 341 domestic wells within the 4-mile TDL. Additionally, based on information gathered from the ADEC, an additional 373 domestic wells are present in the TDL. The total number of wells located within the 4-mile TDL is 714. As noted above, the average household size in Fairbanks North Star Borough is 2.68 people. Based on this number, it is estimated that approximately 1,913 people (714 wells x 2.68 people per household = 1,913 people) utilize domestic drinking water wells.

The nearest well to the site is a domestic drinking water well located 0.25 to 0.50 miles away. A well head protection area is located approximately 0.25 to 0.50 miles north of the site. Ground water is not used for irrigation, for commercial livestock watering, as an ingredient in commercial food preparation, for commercial aquaculture, or as a supply for a major or designated water recreation area within the 4-mile TDL.

Contaminated ground water exists in on-site wells and in domestic and municipal wells off site. Information from the ADEC indicates that sulfolane concentrations range from non-detect to greater than 25 µg/L in both on-site and domestic wells. Currently, no regulatory limit exists for sufolane; however, the ATSDR has recommended a public health action level of 20 µg/L (ATSDR 2011; Barr 2010). Using a sulfolane concentration map for domestic wells sampled through the second quarter of 2011 the number of wells with concentration of sulfolane is estimated as (ADEC 2012):

- From 0 to 0.25 miles
    - 2 wells with non-detects
- From 0.25 to 0.50 miles:
    - 1 well with non-detects
    - 0 wells with detections from non-detect to 25 µg/L
    - 11 wells with detections from 26 to 200 µg/L
    - 3 wells with detections from 201 to 1,000 µg/L
    - 0 wells with detections greater than 1,000 µg/L
- From 0.5 to 1 mile:
    - 6 wells with non-detects L
    - 3 wells with detections from non-detect to 25 µg/L
    - 7 wells with detections from 26 to 200 µg/L
    - 0 wells with detections from 201 to 1,000 µg/L
    - 0 wells with detections greater than 1,000 µg/L
- From 1 to 2 miles:
    - 41 wells with non-detects
    - 12 wells with detections from non-detect to 25 µg/L
    - 57 wells with detections from 26 to 200 µg/L
    - 10 wells with detections from 201 to 1,000 µg/L
    - 0 wells with detections greater than 1,000 µg/L

- From 2 to 3 miles:
  - 162 wells with non-detects
  - 46 wells with detections from non-detect to 25 μg/L
  - 34 wells with detections from 26 to 200 μg/L
  - 0 wells with detections from 201 to 1,000 μg/L
  - 0 wells with detections greater than 1,000 μg/L
- From 3 to 4 miles:
  - 10 wells with nondetects.

Of these 373 wells, 183 have detections of sulfolane. Of the 183 wells with sulfolane detections, 122 had detections of sulfolane greater than 25 μg/L. As stated above, when sulfolane is detected in a domestic drinking water well, the residence using that well was offered an alternate source of drinking water. Alternate sources of drinking water include city water, bottled water, or bulk water. Additionally, it is possible that domestic wells that have not been tested for sulfolane are being used for drinking water. See Figure 3-3 for contaminated domestic wells by distance ring.

3.2 Surface Water Migration Pathway

The surface water migration pathway TDL begins at the probable point of entry of surface water runoff from the site to a surface water body and extends downstream for 15 miles. Figure 3-2 depicts the surface water TDL.

The 2-year, 48-hour rainfall event for North Pole is 2.0 inches (Miller 1965). The average annual precipitation (measured at North Pole) is 11.21 inches (WRCC 2010). Based on the lack of topographic relief at the site, it is not expected that any upgradient areas drain through the site; therefore, the upland drainage area is the NPR's foot print itself, which is approximately 80 acres.

According to the United States Department of Agriculture Soil Survey of the Greater Fairbanks Area, the main soil units near the site are comprised of the Eielson-Tanacross peat and Tanana mucky silt loam (USDA 2004). These soils are classified as follows:

- Tanacross peat: This soil unit forms on alluvial flats, with slopes ranging from 0 to 2 percent. Parent material consists of organic material over alluvium. Depth to permafrost is typically 10 to 28 inches. The likelihood of ponding and/or runoff is high, as this unit is poorly drained (USDA 2004).

- Tanana mucky silt loam: This soil unit forms on terraces, with slopes ranging from 0 to 2 percent. Parent material consists of alluvium and or loess over alluvium. Depth to permafrost is typically 16 to 47 inches. The likelihood of ponding and/or runoff is high, as this unit is poorly drained (USDA 2004).

Flint Hills is located on the Tanana River. Based on Federal Emergency Management Agency flood map (map ID 0250090212H) portions of the site are located in areas that may be inundated by a 100-year flood. These areas are zoned A, indicating that no base flood elevation has been determined (FEMA

2010). However, a flood control levy is in place around Flint Hills, which may reduce the likelihood of flooding (Barr 2010).

3.2.1 Overland Route

Due to the lack of topographic relief in the area, there is no distinct surface water runoff path that drains the site. However, the site does generally slope to the northwest. During heavy rain, water is likely to flow northwest towards the Tanana River. The shortest overland distance between the source and the probable point of entry for surface water leaving the site is approximately 0.27 miles into the Tanana River (Maguire 2010). Once surface water enters the Tanana River, it flows northwest towards Fairbanks. The 15-mile TDL is wholly contained in the Tanana River and concludes west of Fairbanks, near the Fairbanks International Airport.

The average annual flow rate for the Tanana River is 19,380 cubic feet per second (USGS 2010).

3.2.2 Drinking Water Targets

Surface water is not used or usable as a drinking water source within the 15-mile TDL of the site (Ferris 2010). Additionally, surface water is not used for irrigation, watering of commercial livestock, commercial food preparation, or as a major or designated water recreation area within the 15-TDL

3.2.3 Human Food Chain Targets

Sport fishing is known to occur within the 15-mile TDL (ADFG 2010). Based on data obtained from the Alaska Department of Fish and Game, the most current sport catch data are from the 2008 license year. Fish catch data in the Tanana River are reported by fishing location. The TDL is located between Big Delta and Nenana, Alaska (Lingnau 2004; ALRC 2010), which encompass approximately 132 river miles. The START estimates that approximately 11% of the TDL is within this area. Sport catch harvest data by fish species are presented in Table 3-2.

Additionally, personal use (subsistence) fishing occurs within the 15-mile TDL (ADFG 2010). Subsistence fishing, like sport fishing, is reported by area or sub-district. The 15-mile TDL is located within sub-district 6-C, which stretches from the eastern edge of the mouth of the Wood River upstream to the eastern edge of the mouth of the Salcha River (Lingnau 2004; ALRC 2010), approximately 67 miles. The START estimates that approximately 22% of the TDL is within this area. Subsistence catch harvest data by fish species is presented in Table 3-3.

3.2.4 Environmental Targets

Based on National Wetland Inventory Maps, it is estimated that approximately 3.7 miles of wetland frontage exists along the 15-mile TDL. All wetlands are present along the Tanana River. No threatened or endangered species are present within the 15-mile TDL (Maguire 2010).

3.3 Soil Exposure Pathway

The soil exposure pathway is evaluated based on the threat to residents and nearby populations from soil contamination within the first 2 feet of the surface.

3.3.1 Site Setting and Exposed Sources

The site is surrounded by a combination of maintained fence and natural barriers; no public recreation use occurs at the site. Contaminated soils do exist at the site, but the total area of contamination is not known.

3.3.2 Targets

No residences are located within 200 feet of sources at the site. An estimated 250 to 500 employees work at the site. No schools or daycares are located within 200 feet of the site. Approximately 1,202 people reside, and approximately 1,505 attend school, within a 1-mile travel distance of the site. Population by distance ring is presented in Table 3-4.

No resources such as commercial agriculture, livestock production or grazing, or silviculture occur within 200 feet of sources at the site. No terrestrial sensitive environments are present on an area of contamination at the site.

3.4 Air Migration Pathway

The air migration pathway TDL is a 4-mile radius that extends from sources at the site (Figure 3-1).

3.4.1 Human Targets

Approximately 7,976 people reside within the 4-mile TDL (Maguire 2010). Five schools are located within the 4-mile TDL. The total population of students and teachers is approximately 2,422 people (NCES 2012). Approximately 250 to 500 employees work at the site. Population by distance ring is presented in Table 3-4.

3.4.2 Environmental Targets

No commercial agriculture, silviculture, or livestock production occur within one-half mile of sources at the site. Additionally, no designated recreation area is present within one-half mile of sources at the site.

An estimated 2,074.14 acres of wetlands are present within the 4-mile TDL. No threatened or endangered species are present within the 4-mile TDL (Maguire 2010). Wetland acreage by distance ring is presented in Table 3-4.

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4 Summary and Conclusions

Flint Hills operates a petroleum refinery in North Pole, Alaska. The refinery is located outside the city limits of North Pole, approximately 13 miles southeast of Fairbanks, Alaska (Figure 1-1). The Flint Hills refinery occupies approximately 80 acres on a parcel that is approximately 240 acres in size. The property in which Flint Hills is located has always been used as an oil refinery.

Spills of various petroleum products have occurred at the site. Table 2-2 indicates the product released, quantity, and the location of all the spills that have occurred at the site Available sample data have indicated the presence of sulfolane at the site in ground water at or above cleanup levels. This data also indicate that sulfolane had been detected at shallow to moderate depth within the aquifer and has migrated off site.

Approximately 6,309 people use ground water within the 4-mile TDL. The City of North Pole municipal drinking water system consists of two permanent wells, which are located approximately 1 mile east of Flint Hills (Trissel 2012). The North Pole system serves approximately 550 connections, or 1,474 people. In addition to the 1,474 people served by the City of North Pole, approximately 2,422 students and teachers, and 250 to 500 NPR workers, are supplied with drinking water from the city. Tests of raw water from the current city wells have not shown any detections of sulfolane (Trissel 2012).

There are approximately 714 domestic drinking water wells within the 4-mile TDL serving approximately 1,913 people. Sulfolane has been detected in domestic drinking water wells within the 4-mile TDL. Information from the ADEC indicates that sulfolane concentrations range from non-detect to greater than 25 μg/L. Based on the most current sampling results, sulfolane was detected in approximately 183 wells, with 122 of them having detected concentrations above 25 μg/L. Currently, no regulatory limit exists for sulfolane; however, the ATSDR has recommended a public health action level ofof 20 μg/L and ADEC has set an interim cleanup goal of 25 μg/L. (ATSDR 2011; Barr 2010, 2011). All users of wells that have had detections of sulfolane have been offered an alternate sources of ground water; however, it is possible that wells containing sulfolane have not yet been tested and are still being used.

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Tables

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Table 2-1
Sulfolane Content in Gasoline
North Pole Refinery
Flint Hills Resources Alaska, LLC

Date	Product	Season	Sulfolane ppm
Data prior to 1992 is no longer available			
8/13/92	88 Octane	Summer grade	92
11/16/92	87 Octane	Winter grade	231
4/2/94	88 Octane	Winter grade	161
12/17/94	88 Octane	Winter grade	103
7/1/97	87 Octane	Summer grade	316
7/27/98	90 Octane	Summer grade	123
9/16/98	87 Octane	Summer grade	251
4/21/99	90 Octane	Winter grade	868
5/9/99	87 Octane	Summer grade	302
3/13/01	90 Octane	Winter grade	156
4/2/01	Sub grade	Winter grade	191
7/19/01	87 Octane	Summer grade	256
LIMS implemented 2002, maximum amount in an approved tank for each year:			
2002 Max	90 Octane	Winter grade	162
2002 Max	87 Octane	Summer grade	298
2003 Max	90 Octane	Summer grade	24
2003 Max	87 Octane	Winter grade	46
2004 Max	90 Octane	Summer grade	50
2004 Max	87 Octane	Summer grade	184
8/01/04 gasoline spec. for sulfolane was set at 48 ppm			
4/04/05 gasoline spec. for sulfolane was set at 56 ppm			
2005 Max	87 Octane	Winter Grade	52
2005 Max	90 Octane	Winter Grade	53
2006 Max	87 Octane	Winter Grade	53
2006 Max	90 Octane	Summer Grade	22
2007 Max	87 Octane		<2
2007 Max	90 Octane		<2
2008 Max	87 Octane	Summer Grade	55.5
2008 Max	90 Octane	Winter Grade	20
2009 Max	87 Octane		<2
2009 Max	90 Octane		<2

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Table 2-2
Release Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
ND	19770731	Kerosene	100	North Pole Refinery
ND	19770807	Naphtha	150	North Pole Refinery
77-3	19770814	Gasoline	250	North Pole Refinery
77-4	19770902	Naphtha	120	Tank 502 dike
78-2|AL004424	19771001	Naphtha	200	Tank 502 dike
78-1|AL004425	19771226	Crude	150	Heat exchanger
78-3|AL004431	19771228	Naphtha	180	Control room|Crude tower|Utilities Building
78-4|AL004432	19780110	JP-4	50	JP-4 Filter|Loading Rack
78-5|AL004433	19780110	#1 fuel oil	1,000	Load Rack
78-6|AL004434	19780113	JP-4	10	Skid 6
78-9|AL004437	19780115	hago	3	Skid 5
78-11	19780117	JP-4	50	Loading Rack
78-15	19780119	Crude|Kerosene	10	Hot Oil Surge Tank
78-15	19780119	Crude	100	Crude charge pump skid
78-14	19780202	JP-4	12,000	Dike, sump & ditch at Tank 504
	19780203	Return oil	150	Adjacent to return oil pumps
	19780207	Return oil	100	Skid 4 return oil pumps
78-17A|AL004454	19780213	Lube oil	3	Skid 4 return oil pumps
78-18	19780213	JP-4	3	Salt tower
78-19	19780213	Reduced Crude	100	Skid at heat exchangers
78-20|AL004459	19780307	Crude oil	10	North Pole Metering Station
78-21|AL004458	19780317	waste oil	5	Fire water tank
	19780328	#2 Fuel Oil	20	Truck Loading Rack
78-23|AL004463	19780410	Return oil	200	Skid 4 return oil pumps
78-24	19780413	Kerosene	75	Truck Loading Rack
78-25|AL004467	19780805	JP-4	230	Inside Tank 502 dike
ND	19780907	Crude	5	Truck Loading Rack
ND	19781029	Propylene Glycol	1,150	Crude charge pump|Pipe rack|Skid #4
ND	19781031	JP-4	40	Tank 501
ND	19781204	JP-4	1,500	Tank
ND	19781221	JP-4	300	Tank
ND	19791214	#1 Fuel Oil	2,000	Within Tank 509 dike
ND	19800212	JP-4	5,600	Tank
ND	19800923	JP-4	60,000	Surplus DOD Tanks (old bolted tanks along Naphtha Avenue)
81-1|AL004485	19801120	JP-4	100	Tank
81-2|AL004488	19801220	Diesel	220	North Pole Refinery
81-3A|AL004493	19810110	JP-4	1,100	Tank
81-4|AL004496	19810507	Jet-A	200	Tank Car Loading Rack
81-5|AL004498	19810604	JP-4	100	Tank Car Loading Rack
81-6|AL004500	19810803	Jet A-1	50	Rail Loading Terminal
81-7	19810831	Jet A-1	200	Jet fuel tank farm
81-8|AL004504	19811101	Jet A-1	2,000	Tank 508|Tank 509
82-1|AL004511	19811103	#1 Heating|Diesel	150	Train Loading Rack
82-2|AL004513	19811118	#1 Heating	100	Rail Rack|Station 4
82-3	19811204	Jet-A|Kero	3,150	T-509
82-5|AL004526	19820105	Jet A	500	Rail Loading Station|Rail Rack
82-6|AL004528	19820223	Jet A	125	Rail Loading Terminal|Station 1
84-1|AL004536	19820722	Kerosene or Jet B|JP-4	1,000	Gathering sump|Process unit
84-10	19821104	Jet-B	300	Rail Loading Station|Rail Rack
85-1|AL004539	19821111	Jet-A	1,000	Load Rack|Rail Loading Terminal
ND	19840407	#4 Fuel Oil|hago	4,287	Rail Loading Station
ND	19840905	asphalt	200	Asphalt Unit
ND	19850123	Return oil	20	JP-4 Filter Skid
ND	19850125	Kerosene	100	Chemical addition
85-7 | AL004544	19850323	JP-4	17,000	Rail Loading Rack
85-8|AL004545	19850503	Kerosene	600	End of bottom loading rack
ND	19850505	Kerosene	1,000	Asphalt loading rack
86-1|AL004550	19850607	Crude	500	Block valve|North/South Pipe Rack
ND	19850913	asphalt	8,000	Truck Loading Area
86-3 | AL004556	19851002	Wastewater	100	Flow from lagoon west to gravel pit
	19860102	unleaded gas	8,400	Tank 617|Tank Farm
86-8 | AL004564	19860424	Unleaded gasoline	8,400	Tank 617 (near intersection of Williams Ave. and Gasoline Alley)
ND	19860429	hago	2,500	Tank Dike
87-2|AL004589	19861204	Jet-A	900	Jet A filter skid Tank 402 dike
87-5|AL004594	19861212	Oil	200	
87-4|AL004593	19870101	HAGO	20,000	Spread northerly from skids 5 & 6 under the pipe rack
87-6	19870325	Jet-A	15	T-508 Dike
87-7	19870408	Jet-A	15	Old bottoms loading rack
87-8|AL004599	19870408	#2 Diesel	100	Tank 401
87-9|AL004601	19870415	Crude	100	Charge skid
87-10	19870416	Crank case oil	10	Generator Building
87-11|AL004607	19870916	Effluent water	250	Waste water lagoon dike
88-2 | AL004612	19871008	Jet-A	5	Sump 922
88-4|AL004616	19871013	hago|Propylene Glycol	1	North/South Pipe Rack|Salt Dryers
88-5|AL004618	19871111	LAGO	10	Tank 404
88-6	19880115	JP-4|Kero	20	Tank Dike 404
88-7|AL004624	19880426	Jet-A	10	North/South Pipe Rack|Tank Farm

Table 2-2
Release Summary
North Pole Refinery
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Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
	19880627	Mixed products	30	Old Truck Loading Rack
88-8 | AL004628	19880709	JP-4|Kero	20	Sump 05-7
88-9|AL004631	19880715	hago	250	crude unit #1
88-11|AL004635	19880722	hago	5	HAGO Filters
AL004643	19880723	Oil	5	Salt Dryers
	19880922	Oily water	200	Tank 508 dike
AL004647	19881123	Oily Water	140	Sump 05-7
89-4|AL004650	19890114	Jet-A	10	Rail Spur
89-5|AL004653	19890121	hago	100	Rail Loading Rack
90-1	19890204	hago	30	Boiler Building|HAGO Transfer Line to GVEA
90-2	19890512	#1 Diesel	10	Load Rack
90-3	19891227	#2 Diesel	40	Rail Rack Loading Area|Sump 902
90-4	19900115	Jet A	100	Rail Rack
90-6	19900126	hago	30	North/South Pipe Rack
91-1	19900402	Oily Water	120	Lagoon B
91-2	19900417	asphalt|Kerosene	15	Pipe rack
91-3	19900705	JP-4	2,400	Tank 501 Dike
91-4	19910129	Gasoline	100	Rail Loading Rack
91-5	19910404	Kerosene	8,000	Tank 302
91-6	19910619	Asphalt AC-5	200	Asphalt Truck rack
92-1	19910626	#2 Fuel Oil	50	Utility Building
ND	19910709	AC-5	100	Asphalt load rack
ND	19911024	hago	25	Effluent Building|Rail Spur
ND	19920114	Nalco 5376	5	Tank 191
ND	19920328	JP-4	400	Tank dike area around tanks
92-6	19920404	Naphtha	1,250	East end How Baker Unit
92-7	19920422	AC-5	118	Rail Rack Loading Area
92-8	19920517	Crude	5	crude unit #1
92-9	19920612	Av Fuel	4,000	North Pole Refinery
92-11	19920624	Diesel	50	Rail Rack
92-13	19920714	Hydraulic Oil	20	Rail Rack|Spur track
ND	19920805	Return crude	5	crude unit #1|Pipe rack
93-3	19920909	Premium unleaded gasoline	50	Rail Rack
93-4	19921124	Jet A	187	Rail Loading Rack
93-5	19930203	Kerosene	3,600	Rail rack
93-6	19930210	Oily Water	250	Effluent Building|Tank 192
93-8	19930401	Oil	1	Generator Building|Pipe rack
93-9	19930417	Kerosene	30	Rail Spur
93-10	19930423	hago	500	Truck rack
93-12	19930607	unleaded gas	10	Rail Rack Station 4
93-11	19930608	LAGO	5	Distribution Building
93-14	19930610	unleaded	304	Distribution Gas Loading Rack|Station 5
93-15	19930701	JP4	10	Military Skid|Piping manifold
93-16	19930721	waste oil	3	Maintenance Building
93-17	19930728	Kerosene	10	Sump 5103
ND	19930729	Hydrocarbon	30	S-908|Salt tower
93-19	19930825	Oil	51	Rail Loading Rack
ND	19930923	Oily Water	20	Salt tower skid
93-21	19931104	Jet A	1,255	Rail Rack
94-01	19931105	Lubrizol	3	Truck Loading Rack
94-02	19931111	Jet a	11,500	Truck Loading Rack
94-03	19931206	asphalt	5	Rail Tracks
94-04	19940102	asphalt|hago	0.5	Blower Building|Rail Car Steam Header
94-05	19940117	Oily Wastewater	400	Lagoon A
94-06	19940126	#4 Fuel Oil|hago	3	Track #4
94-08	19940130	Effluent water	500	C pond
ND	19940205	FSII	1	FSII Pump Box
94-10	19940315	Resid	1	Resid Pump
94-11	19940331	AC 2.5|ARC|LAGO	5	Truck rack
ND	19940420	Wastewater	400	North of Lagoon B
94-12	19940428	unleaded gas	3	Road by rail sump
94-13	19940430	Wastewater	1,000	Lagoon B
94-15	19940503	#1 Fuel oil	100	North Pole Refinery
94-16	19940517	Kerosene	20	Sump 04-3
94-17	19940607	AC-5	50	Lane 8|Truck Loading Facility
94-18	19940616	Jet A-1	9	Rail Rack Station 2
94-19	19940810	hago	5	Hago salt tower|North/South Pipe Rack
94-20	19940829	AC-5	10	Lane 8|Truck Loading Area
94-21	19940830	Gasoline	1,300	Rail station between tracks 3 & 4
ND	19941003	Resid	1.5	5180 Reject Pump
94-23	19941010	Resid	10	Injection pump 5180 & 397
95-3	19941109	Diesel	870	Rail Loading Rack
ND	19941113	Ethylene Glycol	165	VRU
95-05	19941215	JP-4|Kerosene	10	Pipe rack|Tank 401
95-06	19950413	unleaded gas	200	Rail Rack
092095IR.065|95-09	19950424	Diesel	100	Truck rack
95-11	19950614	FSII	15	FSII Injection Skid

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Release Summary
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Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
ND	19950618	JP-4|unleaded gas	5	Tank 515
ND	19950920	#4 Fuel Oil|hago	10	Skid #5
110995IR.092	19951021	wastewater	30	CTX Box Skid
1116951IR.095	19951101	Additive	313	Additive enclosure and wastewater system
ND	19951109	Jet-A	100	Rail Rack|Station 4
120195IR.107	19951109	Jet-A	103	Rail Rack|Station 4
ND	19951114	HAGO	300	Truck rack paved area only
031796IR.010	19951116	Kerosene	10	CU2 Salt Tower skid
040996IR.016	19951201	Gasoline	100	Lane 1|Truck rack
050196IR.027	19960201	wastewater	10	Blower Building|Lagoon A
051096IR.023	19960315	Slop oil	2	Crude #1 charge pump|Pipe rack
062596IR.038	19960409	Naphtha	15	JP-4 Salt Tower
ND	19960501	Slop oil	300	Utilidor
ND	19960510	Slop oil | Sump Sludge	20	Distribution Rail Loading Sump|Sump 158
100796IR.063	19960625	Resid | Return oil	5	Return oil pipeline
110196IR.075	19960627	Crude	1,200	Crude Unit 1 Desalter
041497IR.028	19960812	Gasoline	94	Truck rack lane 6
ND	19961007	Mixture of Various Hydrocarbon Products		Sump 902
ND	19961101	aromatics|Gasoline	750	Tank 513|Tank Farm
060597IR.050	19970414	Kerosene	10	Crude #1|Slop manifold
	19970425	Gasoline	750	North Pole Refinery
060797IR.46	19970501	Propylene Glycol	7,400	North Pole Refinery
062397IR.056	19970605	Gasoline	1	Infiltration Gallery | Air Stripper Effluent Pond
070797IR.057	19970607	Gasoline	500	Rupture in off-site slop oil line during increase in pressure
ND	19970608	Slop oil	100	S-921 Discharge piping
ND	19970623	Wastewater	100	Sump 903 | Charge skid|crude unit #1
ND	19970707	#1 Diesel	40	Roadway|Truck rack fence line
072997IR.063	19970714	Diesel	200	Truck rack, lane 3
ND	19970718	Crude	500	North Pole Refinery
ND	19970722	Oily Water	100	Ground surrounding sump
ND	19970729	Kerosene	100	Lane 3|Truck Loading Rack
082297IR.078	19970822	Oily Water	100	Sump 908
082397IR.079	19970828	Sulfolane	9	Sulfolane Unit
090897IR.080	19970908	Oily Water	200	Tank 192|Utility Building
ND	19971012	Kerosene	400	New naphtha extraction skid
103107IR.098	19971031	Oily Water	200	Oily water line|Pipe rack
ND	19971107	Wastewater?	100	North Pole Refinery
ND	19971107	Wastewater?	500	North Pole Refinery
111297IR.100	19971112	Oily Water	50	Effluent Building|Sump 905
	19971218	Kerosene	150	Naphtha extractor skid on ground level
020998-IR-6	19980103	Kerosene	10	Auxiliary tank
010698IR.005|98021	19980106	glycol	150	C-Pond|Outlet piping
020998-IR-9	19980108	JP-4	5	Tank Farm
011298IR.004	19980112	Gasoline	0.5	Air Stripper Effluent Pond
980309-IR-28	19980309	glycol	50	JP-4 Filter Skid | Tank Farm
0980520-IR-89	19980520	wastewater	50	Drain line|Lab
980526-IR-96	19980524	Propylene Glycol	200	Asphalt loading pump|Tank Farm
980628-IR-130	19980627	Residual Crude	15	CU1|Pipeline|Piperack
980714-IR-150	19980714	glycol	2	Tank Farm
980827-IR-212	19980826	Propylene Glycol	40	Kero Loading filter|Piperack|Tank Farm
980109-IR-223	19980829	Nalco 5541	150	Crude #1
980921-IR-242	19980830	glycol	4,140	Crude #1 Heating Glycol System|Maintenance Building
980901-IR-222	19980901	unleaded gas	3	Check valve|Pipe rack|Truck rack
ND	19980901	Nalco 5541	150	Secondary containment
ND	19980929	Propylene Glycol	200	Crude Unit #1 Glycol Heater 5005, Secondary containment
981007-IR-262	19981002	Hydrocarbon	5	Gas Skid Sump|Tank Farm
981014-IR-269	19981014	Propylene Glycol	40	CU3|Glycol system
981102-IR-280	19981102	Hydrocarbon	10	Crude 1
ND	19981115	Residual Oil	280	Crude Unit #1 Secondary containment
ND	19981129	Kerosene	1,500	Tank Farm - Sump 922
ND	19990108	Benzene Overhead product	200	Crude Unit #2 BeRT Unit - secondary containment
ND	19990117	Kerosene	300	Truck rack - sump
ND	19990623	Asphalt AC-5	200	Trank Farm - Tank 822 loading skid
93-13	19990721	Oily Water	10	CU1 Resid Stripper
991130-IR-112	19991128	Propylene Glycol	300	Behind Lt. Kero product pumps near the BERT unit by CU2
ND	19991231	Kerosene	488	North Pole Refinery
000127-IR-9	20000126	Gasoline	10	Truck rack|VRU knock out drum
ND	20000216	Kerosene	200	Tank Farm - skid form filter vessel
ND	20000301	Naphtha	150	Rail rack - strainer housing
000511-IR-44	20000509	MEA	10	Crude 2
000522-IR-47	20000522	Oily Wastewater	40	Utility Building
ND	20000525	Diesel	500	North Pole Refinery
000604-IR-52	20000604	#2 LAGO	59	Truck rack
000622-IR-59	20000621	Propylene Glycol	40	Crude 2
000623-IR-61	20000623	glycol	92	crude unit #1
000710-IR-70	20000710	Oily Water	20	Boiler Building|CU1 I/O Building | Utility Building

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Release Summary
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Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
000718-IR-78	20000718	Kerosene	4	Truck rack
000808-IR-84	20000808	#2 Diesel	40	Drain cup|Tank Farm
000814-IR-87	20000813	Desalter water	5	Crude 3|Oily water line
ND	20000821	Propylene Glycol	144	Tank farm
000918-IR-99	20000918	glycol	45	crude unit #2
000920-IR-100	20000920	glycol	50	Crude 2|Hot glycol system
ND	20000920	glycol	800	
000929-IR-105	20000927	Gasoline	250	Tank Farm
001013-IR-115	20001013	Crude	20	Administration building|Crude #1 slop manifold
001014-IR-117	20001013	LAGO	50	Administration building | Tank 402 - NE Corner
ND	20001204	Groundwater	1,000	Tank Farm - Recovery well line
001208-IR-144	20001208	Oily Water	45	crude unit #2|Crude Unit #3
001219-IR-149	20001219	Kero Rich Solvent	30	Extraction Unit
010113-IR-3	20010113	Ground water	200	Tank Farm
010118-IR-9	20010118	Oily Water	5	Crude Unit #3|Oily water line
010122-IR-10	20010122	Kero	50	Rail Rack
010214-IR-17	20010213	glycol	30	Crude 2|East/West Pipe Rack|Glycol trace
010220-IR-23	20010218	Propylene Glycol	240	crude unit #2 | Tank Farm
010219-IR-22	20010219	water/brine	35	CU3 oily water line on CU2 side of Fin Fan Alley|Extraction Unit
010313-IR-30	20010313	Kerosene|Oily Water	20	Oily water line|Tank Farm
010326-IR-39	20010323	glycol	1	Tank Farm
010313-IR-38	20010323	hago	150	Tank Farm
010404-IR-45	20010402	hago	2	Tank Farm
010402-IR-42	20010402	Propylene Glycol	158	Crude 2
010404-IR-46	20010404	Kerosene	5	crude unit #2
010410-IR-52	20010410	Sodium Hydroxide	2	Maintenance Building
010418-IR-69	20010418	K050 wastewater	1	500-bbl tank rented by CEDA from R&K Industrial
010418-IR-68	20010418	K050 wastewater	10	Heat exchanger cleaning skid
010427-IR-91	20010426	Hydrocarbon sulfolane	40	Rail Rack
010501-IR-95	20010430	Kero	20	Rail Rack
010502-IR-96	20010502	hot ARC	1	Asphalt load arm, Station 8|Truck rack
010504-IR-98	20010504	Oily Water	0.5	Crude 1
010508-IR-101	20010507	K050 wastewater	40	Tank Farm
010531-IR-111	20010531	Kero	8	Truck rack
010614-IR-130	20010614	Gasoline	306	Rail Rack
010617-IR-137	20010616	wastewater	300	Benzene Strippers|Crude #1|Inlet line|Tank 198
ND	20010616	HAGO	1,500	Tank Farm HAGO Drier
010629-IR-148	20010629	Propylene Glycol	10	Tank Farm
010706-IR-156	20010706	wastewater	2	crude unit 3
010716-IR-160	20010713	Propylene Glycol	160	Flare Stack | Tank Farm
010726-IR-172	20010725	AC PG 52-28	2	Station 8|Truck rack
010801-IR-176	20010801	wastewater	20	Oily water line near tank 192|Utility Building
010822-IR-191	20010822	hago	5	Sump 904|Tank Farm
010914-IR-213	20010914	Sulfolane	5	Effluent Building|Utility Building
010918-IR-221	20010917	glycol/water mixture	725	Crude 2|Underground heat tracing near salt towers across from Fire Hall
010925-IR-230	20010925	Oily Water	20	Tank Farm
010927-IR-233	20010927	Propylene Glycol	200	Glycol trace|Tank Farm
011115-IR-390	20011115	ANS crude oil	3	Crude 3
ND	20011208	Propylene Glycol	165	Tank Farm
ND	20011211	Kerosene	5	Asphalt piping sample point
011212-IR-486	20011211	Kerosene	5	Tank Farm
020103-IR-5	20020103	Residual oil & kero	2,000	Crude 1
ND	20020209	Propylene Glycol	147	Crude Unit #2 coupler fitting
ND	20020221	Automatic transmission fluid	6	Track machine
020430-IR-585	20020429	Naphtha Wash Water	800	Crude 2
020430-IR-591	20020430	IRIS Inspection Water with very low percentage Kerosene	55	Off-site
020509-IR-723	20020509	Oily Water	5	Crude 2
ND	20020510	ARC	300	Crude Unit #1 Charge Skid Sump
020516-IR-784	20020515	glycol	10	Glycol header|Tank Farm
020516-IR-777	20020515	Sulfolane	75	Crude 1|Portable transfer pump
ND	20020524	Oily Water	1	Sump Drain
ND	20020602	asphalt	3	Asphalt loading arm
020626-IR-1024	20020626	Propylene Glycol	10	Heat trace for CTX stack exhaust|Utility Building
020711-IR-1090	20020711	antistrip	0.25	Truck rack
ND	20020715	Sulfolane	150	Crude Unit #1 Tank 194
020717-IR-1117	20020717	asphalt	20	Truck rack
020719-IR-1128	20020719	asphalt	9	Asphalt loading arm
020819-IR-1278	20020817	wastewater	10	Crude 1
020902-IR-1333	20020831	Kerosene	30	Rail Rack|Strainer screen
020908-IR-1365	20020908	Avgas LL100	5	Truck rack
020914-IR-1395	20020912	Hydraulic Oil	4	Distribution|Track mover
021024-IR-1599	20021021	Propylene Glycol	140	Crude #2
ND	20021031	Kerosene	225	Truck Rack Lane 2 Load Arm
021102-IR-1648	20021102	Hydaulic fluid (oil)	4	Loading Rack
021102-IR-1649	20021102	Propylene Glycol	20	Crude Unit #3|Glycol heat trace
021121-IR-1727	20021121	glycol	280	CU#1|Glycol line|Portable air compressor

Table 2-2
Release Summary
North Pole Refinery
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Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
27931	20090110	Hydaulic fluid	2	North Tank dike
27932	20090112	oily water	8	Utilities Tank 196 | Wastewater piping
81858	20090728	Treated waste water	25	CPS Overflow Sump
31942	20090731	Futurathane 5040 part A	0.008	APC Trailer
33695	20091013	Hydaulic fluid	5	Hydraulic hose|Rail Rack|Track 3|Track machine
34714	20091128	Recovery Well Water	84	Recovery Well #35|Recovery Well #39|Recovery Well Line
34841	20091203	Recovery Well Water	0.125	Discharge valve|Recovery Well #39

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Release Summary
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Facility Tracking Number	Date	Material	Volume Spilled (gallons)	Location
021123-IR-1736	20021123	ethelene glycol	7	Distribution
021127-IR-1750	20021126	glycol	15	Crude 1
021213-IR-1809	20021213	Propylene Glycol	86	crude unit #2|Heat trace|Tank Farm
030311-IR-303	20030311	Jet A	3	Distribution
030407-IR-406	20030406	Kero	2	Distribution
030514-IR-614	20030513	ARC	15	crude unit #1
030515IR.675	20030516	Oily Water	200	railtrack|Sump 5118
030517-IR-698	20030517	AFFF Foam	0.25	Contractor Parking area
030531-IR-835	20030531	antistrip|Pave Bond	2	Anti-strip tank|Truck Loading Rack
030610-IR-890	20030610	hago	30	GVEA Metering Building
ND	20030711	Jet A	7	
030817-IR-1274	20030817	hago	1	crude unit #2|Hago salt tower|Tank Farm
ND	20030903	Propylene Glycol	50	Propylene Glycol heat tracing
030918-IR-1522	20030918	Mineral Oil	50	Gasket|Transformer ET-2101B
031008-IR-1642	20030929	glycol	15	Gravel pad|Tank Farm
031008-IR-1642	20030929	Propylene Glycol	15	Tank Farm
030930-IR-1588	20030930	Oil	3	Tank Farm
031020-IR-1707	20031017	AC 5|ARC	3	Lane 7|Truck rack
031017-IR-1692	20031017	Propylene Glycol	45	NPR Tank Farm
031202-IR-1934	20031202	Crude oil	200	NPR Boiler House (107)
040413-IR-391	20040412	Kerosene	25	Rail Rack
040419-IR-410	20040419	Mineral Oil	5	Crude Unit #3
040422-IR-423	20040422	JP-8|Kerosene	3	Military Skid|Tank Farm
040512-IR-452	20040512	heating oil #2	2	Warehouse Complex
040528-IR-488	20040528	Kero	1	Warehouse Complex
040606-IR-497	20040605	LAGO|Water	5	Tank Farm; Tank 402
ND	20040608	LAGO	4	Lago loading line drain
040608-IR-500	20040608	LAGO	9	Skid 6|Tank Farm
040615-IR-506	20040614	Chromium		Tank Farm
040617-IR-508	20040617	Hydraulic Oil		Rail Loading Rack
040623-IR-518	20040623	Demulsifier; EC2043A	0.5	P-5535
ND	20040623	EC2043A	0.5	
040628-IR-524	20040628	Jet Fuel	250	Rail Rack|Station 1
040630-IR-526	20040629	asphalt	40	Asphalt Truck rack|Lane 7
ND	20040711	LAGO	154	Rail Rack
040722-IR-569	20040722	asphalt	8	Tank Farm
ND	20040731	Kerosene	1,071	Crude Unit #2
ND	20040927	water/oil	5	FHR terminal|SW corner of asphalt scale
ND	20040930	glycol	21	Hot glycol heat trace|North of the terminal building
ND	20040930	glycol	21	Glycol line tracer
ND	20041023	Propylene Glycol	178	East West Pipe Rack
Lynx 5432	20041025	glycol	52	CU#3 Chemical Building|Glycol tracer
ND	20041028	Oily Wastewater	390	Sump 5002
5468	20041108	glycol	15	CU1|Portable air compressor
5501	20041202	ASA Stadis 450	0.001	ASA injection system|Truck Loading Rack
5541	20041227	hydraulic fluid	1	Blend Building|CU#3
ND	20050102	Propylene Glycol	5	CU2 Glycol pipe rack north of Extraction Unit
ND	20050125	Liquid Gas|Water		Sulfatreat
ND	20050405	Propylene Glycol	250	CU3
ND	20050405	glycol	250	Crude Unit #3|Hot glycol system
6951	20050429	Kerosene	5	Tank 302 Foam Chamber Piping
6758	20050529	JP-4	1	Tank 511
7030	20050603	Process water / oily water	8	crude unit 3|Oily water piping
ND	20050624	Sulfolane	0.008	Tank 194 solvent tanks|Tank 194 transfer line
7241	20050910	Asphalt	75	Truck Loading Rack
ND	20051031	Propylene Glycol	20	Fitting|Glycol line|Piperack|Slop manifold
ND	20060116	Nalco 2043	0.016	2043 Bulk Tank|Bulk Tank Dike|Check valve
9795	20060126	Ferric Chloride	110	C pond
ND	20060213	Hitec 6560 Fuel Additive	0.004	Truck rack
10886	20060414	Jet A	100	Rail Rack|Station 2
ND	20060512	Oily Water	600	Exchanger Wash Skid
ND	20060519	Jet Fuel	2	Flange connection|Nap line tie in
ND	20060704	FeCl, Propylene Glycol	162	Ferric Chloride Pump
12331	20060725	Oily water	200	ASIG Pit sump
ND	20060725	glycol	329	crude unit #2; Glycol System
ND	20060917	Kero	3	Fuel terminal
ND	20061216	Jet A	108	Rail Rack
15963	20070426	Jet Fuel	50	Anchorage Railrack
16552	20070606	Pave Bond	0.25	Anchorage Asphalt Yard
17662	20070822	Hydaulic oil	0.13	Maintenance Building
21838|5429	20080422	Fuel oil	1	Maintenance Building parking area
23417	20080709	Oily Water	25	crude unit #2|Hago salt tower|Pipe rack
23587	20080723	Rectifier Vapor/Water	0.125	crude unit #2
6344	20080904	OVHD Desalter Water	50	CU2
25059|6381	20080913	LAGO|Oily Water	15	Sump 908
25060	20080915	waste thinner	0.125	Bucket|Field of Dreams|Gravel field north of CU2
27525	20081212	Propylene Glycol	75	Asphalt Dike|Heat tracing on gasoline load line to rail rack

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Well Screen Depth to Top (feet BGS)	Well Screen Top Elevation (feet MSL)	Well Screen Depth to Bottom (feet BGS)	Well Screen Bottom Elevation (feet MSL)	Well Screen Length (feet)	Well Screen Screen Slot Size (inches)	Well Screen Material	Riser Material	ALASKA STATE PLANE NAD83, ZONE 3 NORTHING	ALASKA STATE PLANE NAD83, ZONE 3 EASTING
Monitoring	MW-169B	10/21/10	485.95	3.00	483.1	49.2	433.9	—	2.0	44.1	439.0	48.7	434.4	4.6	0.020	PVC	PVC	3931960.39	1423037.49
	MW-169C	9/1/11	482.57	-0.70	483.2	59.9	423.2	69.0	2.0	54.8	428.4	59.5	423.7	4.7	0.020	PVC	PVC	3931966.50	1423042.84
	MW-170A	2/24/10	490.82	-0.31	491.1	14.9	476.2	—	2.0	4.6	486.5	14.4	476.7	9.8	0.010	PVC	PVC	3930005.65	1429184.98
	MW-170B	3/6/10	490.72	-0.25	491.0	74.8	416.3	—	4.0	69.7	421.3	74.1	417.0	4.4	0.010	PVC	PVC	3930000.43	1429187.53
	MW-170C	3/4/10	490.85	-0.31	491.2	130.9	360.3	135.0	2.0	125.9	365.3	130.2	361.0	4.3	0.010	PVC	PVC	3929995.96	1429188.84
	MW-170D	10/13/10	490.39	-0.40	490.9	50.6	440.3	—	2.0	45.5	445.4	50.1	440.8	4.6	0.020	PVC	PVC	3929991.96	1429189.27
	MW-171A	2/25/10	484.68	-0.62	485.3	15.2	470.1	—	2.0	5.0	480.3	14.8	470.5	9.8	0.010	PVC	PVC	3935401.97	1428945.84
	MW-171B	3/16/10	484.69	-0.25	485.3	40.3	445.1	42.0	2.0	35.3	450.1	39.7	445.6	4.4	0.010	PVC	PVC	3935402.47	1428941.37
	MW-172A	3/24/10	475.72	-0.40	476.1	15.5	460.7	—	2.0	5.3	470.8	15.0	461.1	9.7	0.010	PVC	PVC	3942632.06	1427431.58
	MW-172B	3/27/10	476.05	-0.22	476.3	150.4	325.9	150.5	2.0	145.4	330.9	149.8	326.5	4.4	0.010	PVC	PVC	3942631.33	1427425.63
	MW-173A	3/31/10	496.16	3.16	493.0	14.6	478.4	—	2.0	4.5	488.5	14.2	478.8	9.7	0.010	PVC	PVC	3927534.58	1430223.98
	MW-173B	3/30/10	496.40	3.17	493.2	150.8	342.4	—	2.0	145.8	347.4	150.2	343.0	4.4	0.010	PVC	PVC	3927527.38	1430222.41
	MW-174A	9/16/10	494.16	2.77	491.4	50.2	441.2	—	2.0	45.0	446.4	49.7	441.7	4.7	0.020	PVC	PVC	3926454.50	1428665.44
	MW-174B	9/15/10	493.28	1.97	491.3	90.4	400.9	—	2.0	85.2	406.2	89.9	401.4	4.7	0.020	PVC	PVC	3926461.30	1428664.22
	MW-175	9/30/10	496.80	2.85	494.0	90.8	403.1	—	2.0	85.8	408.1	90.3	403.7	4.5	0.020	PVC	PVC	3926774.40	1429593.36
	MW-176A	10/4/10	496.99	3.08	493.9	14.8	479.1	—	2.0	4.7	489.2	14.4	479.5	9.8	0.020	PVC	PVC	3926055.80	1429416.30
	MW-176B	10/4/10	496.92	3.06	493.9	50.6	443.3	—	2.0	45.6	448.3	50.1	443.8	4.5	0.020	PVC	PVC	3926056.30	1429412.03
	MW-176C	10/1/10	496.84	3.10	493.7	90.5	403.3	—	2.0	85.4	408.3	89.9	403.8	4.5	0.020	PVC	PVC	3926056.80	1429407.76
	MW-177	9/22/10	497.90	2.92	495.0	89.7	405.3	—	2.0	84.7	410.3	89.2	405.8	4.5	0.020	PVC	PVC	3925072.46	1430037.88
	MW-178A	9/18/10	496.48	2.32	494.2	16.1	478.1	—	2.0	5.9	488.3	15.6	478.5	9.7	0.020	PVC	PVC	3926117.29	1429586.63
	MW-178B	9/18/10	496.09	1.96	494.1	51.2	443.0	—	2.0	46.0	448.1	50.7	443.4	4.7	0.020	PVC	PVC	3926117.08	1429579.97
	MW-178C	9/17/10	497.26	3.10	494.2	90.2	404.0	—	2.0	85.2	409.0	89.9	404.2	4.8	0.020	PVC	PVC	3926117.30	1429573.58
	MW-179A	9/21/10	496.94	2.96	494.0	15.6	478.4	—	2.0	5.6	488.4	15.2	478.8	9.6	0.020	PVC	PVC	3926050.54	1429676.64
	MW-179B	9/21/10	496.74	2.72	494.0	50.8	443.2	—	2.0	45.8	448.2	50.3	443.7	4.5	0.020	PVC	PVC	3926047.16	1429680.75
	MW-179C	9/20/10	497.25	3.22	494.0	90.4	403.6	—	2.0	85.4	408.6	89.9	404.1	4.5	0.020	PVC	PVC	3926045.58	1429674.43
	MW-179D	8/12/11	497.05	3.52	494.0	134.1	360.0	140.5	2.0	129.0	365.1	133.7	360.4	4.7	0.020	PVC	PVC	3926048.88	1429668.63
	MW-180A	9/27/10	497.40	3.06	494.3	15.4	479.0	—	2.0	5.3	489.1	15.0	479.4	9.7	0.020	PVC	PVC	3925874.85	1429928.62
	MW-180B	9/27/10	496.86	2.68	494.2	50.7	443.5	—	2.0	45.7	448.5	50.2	444.0	4.5	0.020	PVC	PVC	3925879.52	1429922.58
	MW-180C	9/25/10	497.05	2.82	494.2	90.4	403.8	—	2.0	85.3	408.9	89.9	404.4	4.5	0.020	PVC	PVC	3925873.80	1429924.19
	MW-181A	10/6/10	475.91	-0.52	476.4	15.2	461.3	—	2.0	5.1	471.4	14.8	461.7	9.7	0.020	PVC	PVC	3944095.46	1425755.04
	MW-181B	10/6/10	476.02	-0.41	476.4	50.8	425.7	—	2.0	45.8	430.7	50.3	426.1	4.5	0.020	PVC	PVC	3944099.95	1425752.10
	MW-181C	10/3/11	475.96	-0.48	476.4	150.5	326.0	—	2.0	145.4	331.0	149.9	326.5	4.4	0.010	PVC	PVC	3944089.21	1425759.17
	MW-182A	10/8/10	475.38	-0.45	475.9	15.8	460.0	—	2.0	5.7	470.2	15.4	460.5	9.7	0.020	PVC	PVC	3941132.12	1423038.13
	MW-182B	8/22/11	475.32	-0.40	475.9	44.7	431.2	46.0	2.0	39.6	436.3	44.3	431.6	4.7	0.020	PVC	PVC	3941136.42	1423037.29
	MW-183A	10/8/10	478.06	-0.55	478.6	15.9	462.7	—	2.0	5.8	472.8	15.5	463.1	9.7	0.020	PVC	PVC	3937529.71	1420159.70
	MW-183B	8/29/11	478.05	-0.62	478.6	59.7	418.9	59.0	2.0	54.6	424.0	59.3	419.3	4.7	0.020	PVC	PVC	3937532.14	1420157.14
	MW-184	10/11/10	486.44	-0.50	486.9	45.2	441.7	45.0	2.0	40.1	446.8	44.8	442.2	4.6	0.020	PVC	PVC	3932560.61	1428756.36
	MW-185A	10/12/10	478.09	-0.60	478.7	15.6	463.1	—	2.0	5.5	473.2	15.1	463.6	9.6	0.020	PVC	PVC	3940802.50	1428251.19
	MW-185B	10/12/10	478.09	-0.60	478.7	51.4	427.3	—	2.0	46.3	432.4	50.9	427.8	4.6	0.020	PVC	PVC	3940797.61	1428251.05
	MW-185C	10/4/11	478.47	-0.50	478.8	121.0	357.8	121.0	2.0	116.0	362.9	120.4	358.4	4.4	0.010	PVC	PVC	3940806.68	1428250.19
	MW-186A	10/19/10	495.95	3.24	492.7	15.2	477.5	—	2.0	5.1	487.6	14.8	477.9	9.7	0.020	PVC	PVC	3927025.87	1429092.83
	MW-186B	10/16/10	495.77	3.09	492.7	60.8	431.9	—	2.0	50.7	442.0	60.4	432.3	9.7	0.020	PVC	PVC	3927021.15	1429092.67
	MW-186C	10/15/10	495.72	3.00	492.7	100.8	391.9	—	2.0	90.7	402.0	100.3	392.4	9.6	0.020	PVC	PVC	3927017.05	1429092.45
	MW-186D	12/4/11	495.13	2.29	492.8	135.0	357.8	—	2.0	129.8	363.0	134.6	358.2	4.8	0.010	PVC	PVC	3927010.35	1429093.23
	MW-187	10/21/10	485.48	3.01	482.5	17.4	465.1	—	2.0	7.3	475.2	16.9	465.6	9.6	0.020	PVC	PVC	3934464.24	1420335.62

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Well Screen: Depth to Top (feet BGS)	Well Screen: Top Elevation (feet MSL)	Well Screen: Depth to Bottom (feet BGS)	Well Screen: Bottom Elevation (feet MSL)	Well Screen: Length (feet)	Well Screen: Screen Slot Size (inches)	Well Screen: Material	Riser Material	ALASKA STATE PLANE NAD83, ZONE 3: NORTHING	ALASKA STATE PLANE NAD83, ZONE 3: EASTING
Monitoring	MW-188	11/24/10	461.39	-0.62	462.0	40.9	421.1	45.5	2.0	35.4	426.6	40.4	421.6	5.0	0.020	PVC	PVC	3951521.76	1410365.52
	MW-189A	8/19/11	470.20	-0.74	470.9	16.5	454.4	—	2.0	6.5	464.5	16.2	454.8	9.7	0.010	PVC	PVC	3945399.36	1424696.44
	MW-189B	8/19/11	470.24	-0.70	470.9	60.5	410.4	—	2.0	55.4	415.5	60.1	410.9	4.7	0.010	PVC	PVC	3945396.24	1424692.19
	MW-190A	8/23/11	481.49	-0.43	481.9	15.6	466.3	—	2.0	5.5	476.4	15.2	466.7	9.7	0.010	PVC	PVC	3938370.06	1429592.42
	MW-190B	8/23/11	481.30	-0.62	481.9	60.7	421.2	—	2.0	55.6	426.3	60.3	421.6	4.7	0.010	PVC	PVC	3938370.16	1429596.16
	MW-191A	8/24/11	475.61	-0.78	476.4	15.3	461.1	—	2.0	5.2	471.2	14.9	461.5	9.7	0.010	PVC	PVC	3937781.57	1417713.87
	MW-191B	8/24/11	475.50	-0.89	476.4	60.3	416.1	—	2.0	55.2	421.2	59.8	416.6	4.6	0.010	PVC	PVC	3937777.89	1417714.18
	MW-192A	8/25/11	495.86	2.42	493.4	14.6	478.8	—	2.0	4.5	488.9	14.2	479.2	9.7	0.020	PVC	PVC	3924992.22	1428889.36
	MW-192B	8/25/11	495.42	2.34	493.1	55.5	437.6	—	2.0	50.4	442.7	55.1	438.0	4.7	0.020	PVC	PVC	3924992.57	1428887.11
	MW-193A	8/30/11	487.61	-0.36	488.0	15.7	472.3	—	2.0	5.0	483.0	15.5	472.5	10.5	0.020	PVC	PVC	3930483.21	1424590.71
	MW-193B	8/30/11	487.31	-0.66	488.0	59.9	428.1	61.0	2.0	54.7	433.3	59.4	428.6	4.7	0.020	PVC	PVC	3930481.25	1424593.75
	MW-194A	8/31/11	475.49	-0.74	476.2	15.8	460.5	—	2.0	6.0	470.2	15.4	460.9	9.4	0.020	PVC	PVC	3939634.55	1418923.90
	MW-194B	8/31/11	475.72	-0.51	476.2	39.5	436.8	39.0	2.0	34.4	441.9	39.0	437.3	4.6	0.020	PVC	PVC	3939630.80	1418924.87
	MW-195A	10/11/11	495.98	2.57	493.4	15.4	478.1	—	2.0	5.2	488.3	15.0	478.5	9.8	0.010	PVC	PVC	3926110.91	1428572.63
	MW-195B	12/5/11	496.09	2.63	493.5	149.9	343.6	—	2.0	144.8	348.7	149.5	344.0	4.7	0.010	PVC	PVC	3926110.92	1428566.32
	MW-196	10/11/11	497.20	3.01	494.2	15.2	479.0	—	2.0	5.0	489.2	14.7	479.5	9.7	0.010	PVC	PVC	3925033.44	1429646.49
	MW-197B	10/16/11	495.27	2.91	492.8	149.7	343.2	—	2.0	144.6	348.2	149.1	343.8	4.5	0.010	PVC	PVC	3926950.83	1429491.74
	MW-198	12/10/11	493.31	-0.29	493.6	149.8	343.8	—	2.0	144.7	348.9	149.4	344.2	4.7	0.010	PVC	PVC	3925820.02	1429027.70
	MW-199	12/2/11	495.89	2.54	493.3	149.8	343.5	—	2.0	144.7	348.7	149.4	343.9	4.8	0.010	PVC	PVC	3926959.18	1428830.82
	MW-300	12/6/11	495.98	1.88	494.0	150.3	343.7	—	2.0	145.0	349.0	149.7	344.3	4.7	0.010	PVC	PVC	3926139.62	1429895.14
	MW-301-CMT-10	10/26/11	492.83	3.37	489.5	10.0	479.5	—	2.0	9.9	479.6	10.1	479.3	0.3	CMT	PVC	PVC	3927444.46	1427850.40
	MW-301-CMT-20	10/26/11	492.83	3.37	489.5	20.0	469.5	—	2.0	19.9	469.6	20.1	469.3	0.3	CMT	PVC	PVC	3927444.46	1427850.40
	MW-301-CMT-30	10/26/11	492.83	3.37	489.5	30.0	459.5	—	2.0	29.9	459.6	30.1	459.3	0.3	CMT	PVC	PVC	3927444.46	1427850.40
	MW-301-CMT-40	10/26/11	492.83	3.37	489.5	40.0	449.5	—	2.0	39.9	449.6	40.1	449.3	0.3	CMT	PVC	PVC	3927444.46	1427850.40
	MW-301CMT-50	10/26/11	492.83	3.37	489.5	50.0	439.5	—	2.0	49.9	439.6	50.1	439.3	0.3	CMT	PVC	PVC	3927444.46	1427850.40
	MW-301-60	10/26/11	492.76	3.12	489.6	60.9	428.8	—	2.0	55.6	434.0	60.3	429.4	4.7	0.010	PVC	PVC	3927435.06	1427867.56
	MW-301-70	10/9/11	492.37	2.72	489.7	70.8	418.9	71.5	2.0	65.7	424.0	70.1	419.5	4.4	0.010	PVC	PVC	3927422.66	1427894.40
	MW-302-CMT-10	10/25/11	494.14	3.41	490.7	10.0	480.7	—	2.0	9.9	480.9	10.1	480.6	0.3	CMT	PVC	PVC	3927605.74	1428194.16
	MW-302-CMT-20	10/25/11	494.14	3.41	490.7	20.0	470.7	—	2.0	19.9	470.9	20.1	470.6	0.3	CMT	PVC	PVC	3927605.74	1428194.16
	MW-302-CMT-30	10/25/11	494.14	3.41	490.7	30.0	460.7	—	2.0	29.9	460.9	30.1	460.6	0.3	CMT	PVC	PVC	3927605.74	1428194.16
	MW-302-CMT-40	10/25/11	494.14	3.41	490.7	40.0	450.7	—	2.0	39.9	450.9	40.1	450.6	0.3	CMT	PVC	PVC	3927605.74	1428194.16
	MW-302-CMT-50	10/25/11	494.14	3.41	490.7	50.0	440.7	—	2.0	49.9	440.9	50.1	440.6	0.3	CMT	PVC	PVC	3927605.74	1428194.16
	MW-302-70	11/5/11	493.13	2.63	490.5	70.9	419.6	—	2.0	65.8	424.8	70.4	420.1	4.7	0.010	PVC	PVC	3927612.39	1428219.37
	MW-302-80	11/3/11	493.34	2.88	490.5	81.5	409.0	—	2.0	76.3	414.1	81.0	409.5	4.7	0.010	PVC	PVC	3927614.39	1428208.27
	MW-302-110	10/17/11	493.48	2.90	490.6	110.2	380.4	110.0	2.0	105.1	385.5	109.6	381.0	4.5	0.010	PVC	PVC	3927616.89	1428196.81
	MW-303-CMT-9	10/20/11	495.88	3.47	492.4	9.0	483.4	—	2.0	8.9	483.5	9.1	483.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-CMT-19	10/20/11	495.88	3.47	492.4	19.0	473.4	—	2.0	18.9	473.5	19.1	473.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-CMT-29	10/20/11	495.88	3.47	492.4	29.0	463.4	—	2.0	28.9	463.5	29.1	463.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-CMT-39	10/20/11	495.88	3.47	492.4	39.0	453.4	—	2.0	38.9	453.5	39.1	453.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-CMT-49	10/20/11	495.88	3.47	492.4	49.0	443.4	—	2.0	48.9	443.5	49.1	443.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-CMT-59	10/20/11	495.88	3.47	492.4	59.0	433.4	—	2.0	58.9	433.5	59.1	433.3	0.3	CMT	PVC	PVC	3927675.95	1428481.84
	MW-303-70	11/1/11	495.03	2.65	492.4	70.4	421.9	—	2.0	65.2	427.1	70.0	422.3	4.8	0.010	PVC	PVC	3927668.05	1428484.37
	MW-303-80	11/2/11	495.09	2.72	492.4	80.7	411.6	—	2.0	75.5	416.8	80.3	412.0	4.8	0.010	PVC	PVC	3927660.37	1428485.11
	MW-303-130	10/18/11	495.12	2.94	492.2	130.7	361.5	130.0	2.0	125.6	366.6	130.2	362.0	4.6	0.010	PVC	PVC	3927682.57	1428479.64
	MW-304-CMT-10	10/18/11	497.59	3.42	494.2	10.0	484.2	—	2.0	9.9	484.3	10.1	484.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Well Screen Depth to Top (feet BGS)	Top Elevation (feet MSL)	Depth to Bottom (feet BGS)	Bottom Elevation (feet MSL)	Length (feet)	Screen Slot Size (inches)	Material	Riser Material	ALASKA STATE PLANE NAD83, ZONE 3 NORTHING	EASTING
Monitoring	MW-101	Apr 1987	494.44	3.30	491.1	61.0	430.1	—	2.0	56.0	435.1	61.0	430.1	5.0	0.020	ss	ss?	3927588.78	1428199.67
	MW-101A	Apr 1987	495.93	4.64	491.3	23.0	468.3	—	2.0	17.8	473.5	22.8	468.5	5.0	0.020	ss	ss?	3927590.29	1428209.63
	MW-102	Apr 1987	495.94	3.40	492.5	71.5	421.0	—	2.5	61.5	431.0	71.5	421.0	10.0	0.010	PVC	PVC?	3927955.12	1429113.91
	MW-104	Apr 1987	496.01	3.05	493.0	67.0	426.0	—	2.5	63.0	430.0	67.0	426.0	4.0	0.020	PVC	PVC?	3927958.82	1429747.75
	MW-105	Apr 1987	497.64	2.44	495.2	63.0	432.2	—	2.0	58.0	437.2	63.0	432.2	5.0	0.020	ss	ss?	3924918.95	1430402.38
	MW-105A	Apr 1987	499.19	3.41	495.8	23.0	472.8	—	2.0	18.0	477.8	23.0	472.8	5.0	0.020	ss	ss?	3924910.02	1430404.24
	MW-106	Nov 1987	499.21	1.41	497.8	23.0	474.8	—	2.0	18.5	479.3	23.0	474.8	4.5	0.020	PVC	PVC?	3926112.10	1428065.05
	MW-109	Aug 1988	495.17	0.34	494.8	14.0	480.8	—	2.0	9.5	485.3	14.0	480.8	4.5	0.020	PVC	PVC?	3925855.20	1428674.99
	MW-110	Aug 1988	496.64	3.34	493.3	18.0	475.3	—	2.0	13.5	479.8	18.0	475.3	4.5	0.020	PVC	PVC?	3925975.36	1428873.06
	MW-111	Sep 88 / Jun 97	493.53	2.12	491.4	19.5	471.9	—	2.0	14.5	476.9	19.5	471.9	5.0	0.020	PVC	PVC?	3926568.20	1428698.07
	MW-113	Sep 1988	494.38	2.97	491.4	16.0	475.4	—	2.0	11.5	479.9	16.0	475.4	4.5	0.020	PVC	PVC?	3926957.71	1428777.98
	MW-115	Sep 1988	495.88	2.61	493.3	17.0	476.3	—	2.0	12.5	480.8	17.0	476.3	4.5	0.020	ss	ss?	3925758.76	1429540.81
	MW-116	Sep 1988	496.19	2.93	493.3	17.0	476.3	—	2.0	12.0	481.3	17.0	476.3	5.0	0.020	ss	ss?	3925670.10	1429332.64
	MW-118	Mar 1990	496.90	3.97	492.9	43.0	449.9	—	2.0	38.5	454.4	43.0	449.9	4.5	0.020	ss	PVC	3927467.01	1429638.43
	MW-124	Jun 1990	497.12	2.92	494.2	24.5	469.7	—	2.0	20.0	474.2	24.5	469.7	4.5	0.020	PVC	PVC?	3927015.09	1429816.83
	MW-125	Jun 1990	497.15	4.07	493.1	24.0	469.1	—	2.0	19.5	473.6	24.0	469.1	4.5	0.020	PVC	PVC	3927032.49	1429569.75
	MW-126	Jun 1991	495.55	3.75	491.8	24.5	467.3	—	2.0	20.0	471.8	24.5	467.3	4.5	0.020	PVC	PVC	3927426.37	1429419.17
	MW-127	Jun 1991	496.36	3.46	492.9	24.5	468.4	—	2.0	20.0	472.9	24.5	468.4	4.5	0.020	PVC	PVC	3927476.29	1429065.47
	MW-129	Oct 1996	496.06	3.26	492.8	41.5	451.3	—	2.0	37.0	455.8	41.5	451.3	4.5	0.020	PVC	PVC	3927205.45	1429720.22
	MW-130	Apr 1997	496.87	2.76	494.1	23.0	471.1	—	2.0	19.0	475.1	23.0	471.1	4.0	0.020	PVC	PVC	3926825.66	1429354.64
	MW-131	Jul 1998	495.69	1.79	493.9	24.5	469.4	—	2.0	20.0	473.9	24.5	469.4	4.5	0.020	PVC	PVC	3927936.24	1429024.82
	MW-132	Sep 1999	499.44	2.24	497.2	22.0	475.2	—	2.0	17.5	479.7	22.0	475.2	4.5	0.020	PVC	PVC	3926600.34	1429997.01
	MW-133	Sep 1999	498.36	2.06	496.3	22.0	474.3	—	2.0	17.5	478.8	22.0	474.3	4.5	0.020	PVC	PVC	3926597.42	1430160.18
	MW-134	Sep 1999	497.79	2.55	495.2	21.5	473.7	—	2.0	17.0	478.2	21.5	473.7	4.5	0.020	PVC	PVC	3926000.91	1430170.26
	MW-135	Mar 2001	496.93	3.45	493.5	19.5	474.0	—	2.0	10.6	482.9	19.5	474.0	8.9	0.020	PVC	PVC	3927024.53	1429730.91
	MW-136	Mar 2001	496.93	2.91	494.0	19.1	474.9	—	2.0	10.1	483.9	19.1	474.9	9.0	0.020	PVC	PVC	3927024.41	1429778.02
	MW-137	Mar 2001	497.45	3.65	493.8	19.3	474.5	—	2.0	10.4	483.4	19.3	474.5	8.9	0.020	PVC	PVC	3927083.81	1429737.46
	MW-138	Apr 2001	496.34	3.09	493.3	18.1	475.2	—	2.0	3.9	489.4	18.1	475.2	14.2	0.020	PVC	PVC	3925738.32	1429686.77
	MW-139	May 2001	497.18	1.89	495.3	25.0	470.3	—	2.0	5.7	489.6	25.0	470.3	19.3	0.020	PVC	PVC	3927427.97	1428848.56
	MW-140	May 2001	494.85	2.69	492.2	23.5	468.7	—	2.0	4.2	488.0	23.5	468.7	19.3	0.020	PVC	PVC	3927683.10	1429244.57
	MW-141	Oct 2001	492.39	2.12	490.3	22.4	467.9	—	2.0	7.9	482.4	22.4	467.9	14.5	0.020	PVC	PVC	3927598.03	1427540.67
	MW-142	Aug 2001	496.08	3.10	493.0	19.4	473.6	—	2.0	5.4	487.6	19.4	473.6	14.0	0.020	PVC	PVC	3927602.87	1428813.48
	MW-143	Aug 2005	495.23	3.35	491.9	19.5	472.4	—	2.0	4.7	487.2	19.5	472.4	14.8	0.020	PVC	PVC	3927688.65	1428487.50
	MW-144A	Sep 2005	495.25	1.69	493.6	24.7	468.9	—	2.0	5.7	487.9	24.7	468.9	19.0	0.020	PVC	PVC	3927485.68	1429623.04
	MW-144BR	9/21/11	494.99	2.67	492.3	90.5	401.8	—	2.0	85.4	406.9	89.9	402.4	4.5	0.010	PVC	PVC	3927483.20	1429632.06
	MW-145	Aug 2005	495.61	2.91	492.7	19.0	473.7	—	2.0	4.7	488.0	19.0	473.7	14.3	0.020	PVC	PVC	3927212.61	1429712.57
	MW-146A	Sep 2008	495.07	2.74	492.3	16.0	476.3	—	2.0	6.0	486.3	16.0	476.3	10.0	0.020	PVC	PVC	3927201.05	1427049.42
	MW-146B	Sep 2008	494.95	2.40	492.6	28.0	464.6	—	2.0	22.0	470.6	27.0	465.6	5.0	0.020	PVC	PVC	3927193.28	1427048.17
	MW-147A	Oct 2008	491.90	2.32	489.6	13.0	476.6	—	2.0	3.0	486.6	13.0	476.6	10.0	0.020	PVC	PVC	3927723.21	1427288.46
	MW-147B	Sep 2008	492.57	2.82	489.8	26.0	463.8	—	2.0	20.5	469.3	25.5	464.3	5.0	0.020	PVC	PVC	3927729.22	1427290.37
	MW-148A	Oct 2008	492.99	2.08	490.9	15.0	475.9	—	2.0	5.0	485.9	15.0	475.9	10.0	0.020	PVC	PVC	3928675.03	1428153.49
	MW-148B	Oct 2008	493.25	2.96	490.3	29.0	461.3	—	2.0	22.0	468.3	27.0	463.3	5.0	0.020	PVC	PVC	3928677.21	1428158.65
	MW-148C	9/27/11	493.05	2.64	490.4	55.7	434.7	—	2.0	50.7	439.7	55.2	435.3	4.4	0.010	PVC	PVC	3928670.73	1428140.18
	MW-148D	9/26/11	493.32	2.98	490.3	151.0	339.4	151.5	2.0	145.9	344.4	150.4	340.0	4.4	0.010	PVC	PVC	3928673.10	1428146.93
	MW-149A	Oct 2008	493.65	3.10	490.6	14.0	476.6	—	2.0	4.0	486.6	14.0	476.6	10.0	0.020	PVC	PVC	3928676.81	1428953.13

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Well Screen: Depth to Top (feet BGS)	Well Screen: Top Elevation (feet MSL)	Well Screen: Depth to Bottom (feet BGS)	Well Screen: Bottom Elevation (feet MSL)	Well Screen: Length (feet)	Well Screen: Screen Slot Size (inches)	Well Screen: Material	Riser Material	ALASKA STATE PLANE NAD83, ZONE 3: NORTHING	ALASKA STATE PLANE NAD83, ZONE 3: EASTING
Monitoring	MW-149B	Oct 2008	493.34	2.64	490.7	21.0	469.7	—	2.0	14.0	476.7	19.0	471.7	5.0	0.020	PVC	PVC	3928677.69	1428959.56
	MW-150A	10/2/09	487.03	-0.54	487.6	11.6	476.0	—	2.0	6.7	480.9	11.1	476.5	4.4	0.010	PVC	PVC	3930163.44	1426522.55
	MW-150B	10/2/09	487.20	-0.32	487.5	24.6	462.9	—	2.0	20.6	466.9	24.5	463.0	3.9	0.010	PVC	PVC	3930162.06	1426527.97
	MW-151A	10/7/09	487.09	-0.53	487.6	15.5	472.1	—	2.0	10.0	477.6	15.0	472.6	5.0	0.010	PVC	PVC	3930152.81	1427042.16
	MW-151B	10/2/09	487.07	-0.64	487.7	23.6	464.1	—	2.0	18.5	469.2	23.1	464.6	4.6	0.010	PVC	PVC	3930154.30	1427034.87
	MW-151C	2/18/10	491.02	3.21	487.8	57.7	430.1	65.0	2.0	52.6	435.3	57.2	430.7	4.6	0.010	PVC	PVC	3930151.93	1427038.65
	MW-152A	10/7/09	488.40	-0.24	488.6	16.0	472.6	—	2.0	10.6	478.0	15.0	473.6	4.4	0.010	PVC	PVC	3930112.63	1427987.59
	MW-152B	10/7/09	488.00	-0.51	488.5	25.4	463.1	—	2.0	19.9	468.6	24.4	464.1	4.5	0.010	PVC	PVC	3930112.89	1427983.05
	MW-152C	9/28/11	488.10	-0.68	488.8	65.2	423.6	67.5	2.0	60.1	428.7	64.6	424.2	4.4	0.010	PVC	PVC	3930113.17	1427992.07
	MW-153A	10/7/09	490.17	-0.35	490.5	16.0	474.5	—	2.0	10.6	479.9	14.5	476.0	3.9	0.010	PVC	PVC	3928749.86	1427720.55
	MW-153B	4/20/10	489.73	-0.58	490.3	56.7	433.7	59.0	2.0	51.6	438.7	56.1	434.2	4.5	0.010	PVC	PVC	3928741.21	1427721.08
	MW-154A	10/5/09	497.99	2.82	495.2	75.5	419.7	—	2.0	71.0	424.2	75.0	420.2	4.0	0.010	PVC	PVC	3927391.51	1428835.89
	MW-154B	2/20/10	497.68	2.61	495.1	95.0	400.1	102.0	2.0	90.2	404.9	94.8	400.3	4.6	0.010	PVC	PVC	3927410.23	1428845.45
	MW-155A	11/11/09	488.16	-0.52	488.7	15.5	473.2	—	2.0	5.4	483.3	15.1	473.6	9.7	0.010	PVC	PVC	3930320.08	1425509.58
	MW-155B	9/11/10	488.21	-0.50	488.7	65.8	422.9	67.0	2.0	60.8	427.9	65.2	423.5	4.4	0.020	PVC	PVC	3930314.75	1425510.07
	MW-156A	11/12/09	485.83	-0.33	486.2	15.5	470.7	—	2.0	5.4	480.8	15.1	471.1	9.7	0.010	PVC	PVC	3931955.04	1425536.52
	MW-156B	2/17/10	489.29	2.99	486.3	50.4	435.9	51.5	2.0	45.2	441.1	50.0	436.3	4.8	0.010	PVC	PVC	3931949.92	1425537.02
	MW-157A	11/13/09	485.00	-0.55	485.6	15.5	470.1	—	2.0	5.4	480.2	15.1	470.5	9.7	0.010	PVC	PVC	3932561.84	1426870.93
	MW-157B	9/30/11	484.72	-0.68	485.4	30.7	454.7	40.0	2.0	25.7	459.7	30.1	455.3	4.4	0.010	PVC	PVC	3932567.15	1426874.11
	MW-158A	11/13/09	487.83	-0.46	488.3	15.6	472.7	—	2.0	5.5	482.8	15.2	473.1	9.7	0.020	PVC	PVC	3931120.65	1426869.14
	MW-158B	9/23/10	487.38	-0.65	488.0	60.6	427.4	65.0	2.0	55.6	432.4	60.1	427.9	4.5	0.020	PVC	PVC	3931119.26	1426874.85
	MW-159A	11/13/09	488.42	-0.56	489.0	15.6	473.4	—	2.0	5.5	483.5	15.2	473.8	9.7	0.020	PVC	PVC	3931101.34	1427690.57
	MW-159B	10/12/11	488.20	-0.87	489.1	46.2	442.9	—	2.0	41.2	447.9	45.6	443.5	4.4	0.010	PVC	PVC	3931101.12	1427679.28
	MW-159C	9/29/11	488.63	-0.50	489.1	72.3	416.8	72.5	2.0	67.1	422.0	71.8	417.3	4.7	0.010	PVC	PVC	3931100.83	1427684.86
	MW-160A	11/13/09	485.48	-0.34	485.8	15.5	470.3	—	2.0	5.4	480.5	15.1	470.7	9.7	0.010	PVC	PVC	3932566.91	1427463.18
	MW-160B	2/19/10	485.53	-0.21	485.7	90.7	395.0	91.0	2.0	85.6	400.2	90.2	395.6	4.6	0.010	PVC	PVC	3932566.90	1427459.68
	MW-161A	12/9/09	479.42	-0.40	479.8	15.6	464.2	—	2.0	5.5	474.3	15.2	464.6	9.7	0.020	PVC	PVC	3935554.06	1421680.78
	MW-161B	9/10/10	479.58	-0.24	479.8	50.4	429.4	—	2.0	46.0	433.8	50.4	429.4	4.4	0.020	PVC	PVC	3935553.83	1421678.29
	B-161	8/18/11	Boring installed to a depth of 54 feet NO WELL					54.0											
	MW-162A	11/25/09	483.94	-0.60	484.5	15.6	468.9	—	2.0	5.5	479.0	15.2	469.3	9.7	0.020	PVC	PVC	3934831.10	1425571.90
	MW-162B	2/21/10	484.12	-0.29	484.4	65.4	419.0	67.5	2.0	60.2	424.2	64.7	419.7	4.6	0.010	PVC	PVC	3934825.07	1425574.08
	MW-163A	12/9/09	485.05	-1.00	485.2	15.6	469.6	—	2.0	5.5	479.7	15.2	470.0	9.7	0.020	PVC	PVC	3935430.75	1426901.11
	MW-163B	9/13/10	485.16	-0.45	485.4	39.6	445.8	40.0	2.0	34.5	450.9	39.0	446.4	4.4	0.020	PVC	PVC	3935430.72	1426906.78
	MW-164A	12/10/09	480.01	-1.00	480.3	15.6	464.7	—	2.0	5.5	474.8	15.2	465.1	9.7	0.020	PVC	PVC	3938026.16	1425651.07
	MW-164B	9/9/10	479.35	-0.45	480.3	50.7	429.6	—	2.0	45.6	434.7	50.1	430.2	4.4	0.020	PVC	PVC	3938027.01	1425654.08
	MW-164C	8/17/11	479.50	-0.50	480.3	62.4	417.9	63.0	2.0	57.3	423.0	62.0	418.3	4.7	0.010	PVC	PVC	3938023.06	1425652.19
	MW-165A	1/18/10	475.07	-0.40	475.5	15.4	460.1	—	2.0	5.2	470.3	14.9	460.6	9.7	0.010	PVC	PVC	3938692.18	1416849.70
	MW-165B	9/28/10	474.78	-0.70	475.6	50.9	424.7	—	2.0	45.9	429.7	50.4	425.3	4.5	0.020	PVC	PVC	3938690.33	1416854.17
	MW-166A	1/8/10	474.92	2.70	472.2	15.6	456.6	—	2.0	5.4	466.8	15.2	457.1	9.7	0.010	PVC	PVC	3940972.27	1419512.27
	MW-166B	3/15/10	475.11	3.00	472.2	32.1	440.1	33.0	2.0	27.2	445.1	31.4	440.9	4.2	0.010	PVC	PVC	3940967.37	1419509.53
	MW-167A	1/7/10	475.68	-0.36	476.0	15.8	460.2	—	2.0	5.7	470.4	15.4	460.7	9.7	0.010	PVC	PVC	3942809.92	1423092.52
	MW-167B	3/23/10	475.82	-0.25	476.0	33.3	442.7	33.5	2.0	28.2	447.8	33.2	442.9	5.0	0.010	PVC	PVC	3942813.73	1423092.51
	MW-168A	1/8/10	478.27	-0.15	478.7	15.5	463.2	—	2.0	5.4	473.4	15.1	463.7	9.7	0.010	PVC	PVC	3941284.64	1425723.88
	MW-168B	10/1/11	478.34	-0.50	478.7	51.5	427.3	55.0	2.0	46.3	432.4	51.0	427.7	4.7	0.010	PVC	PVC	3941289.40	1425724.13
	MW-169A	2/25/10	486.13	3.01	483.1	15.2	468.0	—	2.0	5.3	477.9	15.1	468.1	9.8	0.010	PVC	PVC	3931955.69	1423035.08

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

										Well Screen								ALASKA STATE PLANE NAD83, ZONE 3	
Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Depth to Top (feet BGS)	Top Elevation (feet MSL)	Depth to Bottom (feet BGS)	Bottom Elevation (feet MSL)	Length (feet)	Screen Slot Size (inches)	Material	Riser Material	NORTHING	EASTING
Monitoring	MW-304-CMT-20	10/18/11	497.59	3.42	494.2	20.0	474.2	—	2.0	19.9	474.3	20.1	474.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58
	MW-304-CMT-30	10/18/11	497.59	3.42	494.2	30.0	464.2	—	2.0	29.9	464.3	30.1	464.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58
	MW-304-CMT-40	10/18/11	497.59	3.42	494.2	40.0	454.2	—	2.0	39.9	454.3	40.1	454.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58
	MW-304-CMT-50	10/18/11	497.59	3.42	494.2	50.0	444.2	—	2.0	49.9	444.3	50.1	444.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58
	MW-304-CMT-60	10/18/11	497.59	3.42	494.2	60.0	434.2	—	2.0	59.9	434.3	60.1	434.0	0.3	CMT	PVC	PVC	3927758.31	1428860.58
	MW-304-70	10/20/11	496.94	2.72	494.2	70.7	423.6	—	2.0	65.5	428.7	70.2	424.0	4.7	0.010	PVC	PVC	3927751.83	1428854.08
	MW-304-80	10/31/11	496.69	2.67	494.0	81.1	412.9	—	2.0	76.0	418.0	80.7	413.4	4.7	0.010	PVC	PVC	3927740.60	1428843.75
	MW-304-125	10/14/11	497.09	3.30	493.8	125.9	367.9	—	2.0	120.9	372.9	125.3	368.5	4.4	0.010	PVC	PVC	3927730.33	1428833.79
	MW-304-150	12/12/11	Not surveyed	2.86	Not surveyed	150.7	Not surveyed	—	2.0	145.5	Not surveyed	150.2	Not surveyed	4.7	0.010	PVC	PVC	Not surveyed	Not surveyed
	MW-305-CMT-8	10/24/11	496.33	3.20	493.1	7.5	485.6	—	2.0	7.4	485.8	7.6	485.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-CMT-18	10/24/11	496.33	3.20	493.1	17.5	475.6	—	2.0	17.4	475.8	17.6	475.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-CMT-28	10/24/11	496.33	3.20	493.1	27.5	465.6	—	2.0	27.4	465.8	27.6	465.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-CMT-38	10/24/11	496.33	3.20	493.1	37.5	455.6	—	2.0	37.4	455.8	37.6	455.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-CMT-48	10/24/11	496.33	3.20	493.1	47.5	445.6	—	2.0	47.4	445.8	47.6	445.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-CMT-58	10/24/11	496.33	3.20	493.1	57.5	435.6	—	2.0	57.4	435.8	57.6	435.5	0.3	CMT	PVC	PVC	3927940.69	1429048.97
	MW-305-70	10/22/11	495.58	2.76	492.8	70.4	422.5	—	2.0	65.0	427.8	69.9	422.9	4.9	0.010	PVC	PVC	3927953.08	1429040.73
	MW-305-80	10/30/11	495.35	2.66	492.7	81.2	411.5	—	2.0	76.1	416.6	80.8	411.9	4.7	0.010	PVC	PVC	3927959.70	1429046.56
	MW-305-100	10/8/11	495.67	2.68	493.0	99.9	393.1	110.0	2.0	94.9	398.1	99.3	393.7	4.4	0.010	PVC	PVC	3927946.36	1429034.54
	MW-306-CMT-10	10/27/11	496.92	3.36	493.6	10.0	483.6	—	2.0	9.9	483.7	10.1	483.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-CMT-20	10/27/11	496.92	3.36	493.6	20.0	473.6	—	2.0	19.9	473.7	20.1	473.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-CMT-30	10/27/11	496.92	3.36	493.6	30.0	463.6	—	2.0	29.9	463.7	30.1	463.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-CMT-40	10/27/11	496.92	3.36	493.6	40.0	453.6	—	2.0	39.9	453.7	40.1	453.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-CMT-50	10/27/11	496.92	3.36	493.6	50.0	443.6	—	2.0	49.9	443.7	50.1	443.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-CMT-60	10/27/11	496.92	3.36	493.6	60.0	433.6	—	2.0	59.9	433.7	60.1	433.4	0.3	CMT	PVC	PVC	3928108.33	1429306.73
	MW-306-70	11/6/11	496.68	3.32	493.4	70.7	422.7	—	2.0	65.5	427.9	70.3	423.1	4.8	0.010	PVC	PVC	3928115.77	1429309.12
	MW-306-80	11/7/11	496.50	3.02	493.5	80.5	413.0	—	2.0	75.3	418.2	80.1	413.4	4.8	0.010	PVC	PVC	3928108.87	1429292.74
	MW-306-100	10/13/11	495.51	2.32	493.2	100.6	392.6	—	2.0	95.4	397.8	100.2	393.0	4.8	0.010	PVC	PVC	3928121.97	1429302.41
	MW-306-150	10/7/11	496.00	2.79	493.2	150.1	343.2	—	2.0	144.9	348.4	149.6	343.6	4.8	0.010	PVC	PVC	3928118.47	1429293.75
	MW-307	12/3/11	495.48	2.52	492.9	149.9	343.0	—	2.0	144.8	348.2	149.6	343.4	4.8	0.010	PVC	PVC	3926951.83	1429734.66
Observation	O-1	9/23/10	497.15	2.54	494.6	15.1	479.5	—	2.0	4.9	489.7	14.7	479.9	9.7	0.020	PVC	PVC	3925973.83	1429619.47
	O-2	9/23/10	496.84	2.99	493.9	15.0	478.8	—	2.0	4.9	489.0	14.6	479.2	9.7	0.020	PVC	PVC	3927114.04	1429130.05
	O-3	9/23/10	497.67	3.23	494.4	14.6	479.9	—	2.0	4.4	490.0	14.2	480.3	9.7	0.020	PVC	PVC	3927090.75	1429551.50
	O-4	9/16/10	496.47	2.63	493.8	15.1	478.7	—	2.0	5.0	488.9	14.6	479.2	9.7	0.020	PVC	PVC	3927159.11	1428795.47
	O-5	9/13/11	496.05	2.55	493.5	15.1	478.4	—	2.0	5.0	488.5	14.7	478.8	9.7	0.010	PVC	PVC	3926951.41	1428829.08
	O-6	9/14/11	494.52	2.22	492.3	15.6	476.7	—	2.0	5.5	486.8	15.2	477.1	9.7	0.010	PVC	PVC	3926744.06	1428769.81
	O-7	9/14/11	495.95	2.28	493.7	15.3	478.3	—	2.0	5.2	488.5	14.9	478.8	9.7	0.010	PVC	PVC	3926757.84	1429941.88
	O-8	9/15/11	496.71	2.66	494.1	15.9	478.2	—	2.0	5.8	488.3	15.5	478.6	9.7	0.010	PVC	PVC	3926131.00	1429895.90
	O-9	9/15/11	496.89	3.09	493.8	15.1	478.7	—	2.0	5.0	488.8	14.7	479.1	9.7	0.010	PVC	PVC	3926505.32	1429912.51
	O-10	9/16/11	496.21	2.59	493.6	16.4	477.3	—	4.0	6.4	487.2	16.0	477.6	9.7	0.010	PVC	PVC	3926386.30	1429760.78
	O-11	9/20/11	497.86	2.83	495.0	16.4	478.6	—	2.0	6.4	488.6	15.9	479.1	9.5	0.010	PVC	PVC	3927247.94	1429025.71
	O-12	9/21/11	496.12	2.99	493.1	17.0	476.1	—	2.0	6.8	486.3	16.6	476.5	9.8	0.010	PVC	PVC	3927268.21	1429161.41
	O-13	9/21/11	495.35	2.88	492.5	15.9	476.6	—	2.0	5.7	486.8	15.5	477.0	9.8	0.010	PVC	PVC	3927268.35	1429254.10
	O-14	10/1/11	494.89	-0.37	495.3	15.3	480.0	—	2.0	5.1	490.1	14.9	480.4	9.8	0.010	PVC	PVC	3925995.33	1430224.22
	O-15	10/6/11	498.62	2.98	495.6	15.4	480.3	—	2.0	5.2	490.5	15.0	480.7	9.8	0.010	PVC	PVC	3925553.75	1430177.50
	O-16	10/7/11	Not surveyed	-0.50	Not surveyed	14.6	Not surveyed	—	2.0	4.4	Not surveyed	14.2	Not surveyed	9.8	0.010	PVC	PVC	Not surveyed	Not surveyed

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

										Well Screen								ALASKA STATE PLANE NAD83, ZONE 3	
Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Depth to Top (feet BGS)	Top Elevation (feet MSL)	Depth to Bottom (feet BGS)	Bottom Elevation (feet MSL)	Length (feet)	Screen Slot Size (inches)	Material	Riser Material	NORTHING	EASTING
Observation	O-17	10/13/11	493.23	-0.44	493.7	15.0	478.6	—	2.0	4.9	488.8	14.6	479.1	9.7	0.010	PVC	PVC	3926546.15	1429036.74
	O-18	10/12/11	492.66	-0.46	493.1	15.3	477.8	—	2.0	5.2	488.0	14.9	478.3	9.7	0.010	PVC	PVC	3926309.43	1429007.34
	O-19	10/15/11	496.44	3.06	493.4	15.3	478.0	—	2.0	5.2	488.2	14.9	478.5	9.7	0.010	PVC	PVC	3926814.98	1429229.93
	O-20	10/13/11	497.42	3.12	494.3	15.8	478.5	—	2.0	5.6	488.7	15.4	478.9	9.8	0.010	PVC	PVC	3925863.81	1429729.04
	O-21	10/14/11	493.12	-0.46	493.6	15.7	477.9	—	2.0	5.5	488.1	15.3	478.3	9.8	0.010	PVC	PVC	3925656.97	1429631.77
	O-22	11/14/11	496.73	1.90	494.8	18.6	476.2	—	2.0	8.3	486.5	18.1	476.8	9.8	0.010	PVC	PVC	3926789.25	1430139.00
	O-23	12/5/11	495.83	2.23	493.6	16.3	477.3	—	2.0	6.0	487.6	15.8	477.8	9.8	0.010	PVC	PVC	3927110.81	1429926.50
	O-24	11/10/11	496.86	2.39	494.5	15.2	479.2	—	2.0	5.0	489.5	14.7	479.8	9.8	0.010	PVC	PVC	3927281.16	1429428.42
	O-25	11/10/11	497.74	2.44	495.3	16.4	478.9	—	2.0	6.1	489.2	15.9	479.4	9.8	0.010	PVC	PVC	3927402.44	1429242.45
	O-26	11/9/11	496.79	2.79	494.0	15.0	479.0	—	2.0	4.7	489.3	14.4	479.6	9.8	0.010	PVC	PVC	3927363.19	1429037.48
	O-27	11/10/11	496.84	1.91	494.9	17.4	477.6	—	2.0	7.1	487.9	16.8	478.1	9.8	0.010	PVC	PVC	3927278.05	1428804.68
	O-28	11/14/11	494.62	2.06	492.6	14.8	477.7	—	2.0	4.6	488.0	14.3	478.3	9.8	0.010	PVC	PVC	3925637.58	1428886.20
	O-29	11/12/11	498.59	2.35	496.2	18.2	478.1	—	2.0	7.9	488.4	17.6	478.6	9.8	0.010	PVC	PVC	3926600.52	1430083.48
	S-9	Aug 2001	495.11	2.80	492.3	19.8	?		2.0	4.9	487.4	18.9	473.4	14.0	0.010	PVC	PVC	3927494.32	1429112.46
	S-20†	May 1987	498.00	1.80	496.2	12.1	?		2.0	2.7	493.5	12.5	483.8	9.8	0.020	PVC	PVC		
	S-21	May 1987	497.16	2.40	494.8	13.4	?		2.0	2.9	491.8	12.7	482.1	9.8	0.020	PVC	PVC	3926670.65	1429597.64
	S-22	May 1987	496.70	1.90	494.8	14.7	?		2.0	4.5	490.3	14.2	480.6	9.7	0.020	PVC	PVC	3926430.46	1429717.90
	S-23†	Sep 1986	498.25	4.02	494.2	13.6	?		2.0	3.5	490.7	12.9	481.4	9.3	0.020	PVC	PVC		
	S-32	Nov 1987	495.69	2.60	493.1	11.3	?		4.0	1.3	491.8	11.3	481.8	10.0	0.020	ABS	ABS	3926946.66	1429732.57
	S-34	Dec 1989	?	?	?	13.0	?		?	7.9	?	12.9	?	5.0	?	?	?		
	S-37†	Dec 1989	500.59	7.30	493.3	12.0	?		?	6.8	486.5	11.8	481.5	5.0	?	?	?	3926645.38	1429730.56
	S-38†	Dec 1989	499.30	5.80	493.5	13.0	?		?	7.9	485.6	12.9	480.6	5.0	?	?	?	3926817.13	1429386.00
	S-39	Dec 1989	497.11	4.01	493.1	13.0	?		?	7.5	485.6	12.5	480.6	5.0	?	?	?	3927009.82	1429395.60
	S-40†	Dec 1989	493.62	0.01	493.6	13.0	?		?	7.8	485.9	12.8	480.9	5.0	?	?	?	3927031.64	1429617.37
	S-41†	May 1990	497.83	1.93	495.9	17.0	?		?	12.1	483.8	16.5	479.4	4.5	?	?	?		
	S-43	June 1991	496.13	1.98	494.2	13.0	?		?	3.4	490.8	12.7	481.5	9.3	?	?	?	3926779.68	1429530.33
	S-44	June 1991	495.69	2.61	493.1	13.0	?		?	3.2	489.9	12.6	480.4	9.5	?	?	?	3926922.12	1429493.51
	S-50	July 1997	496.67	3.24	493.4	15.0	?		4.0	3.9	489.6	13.6	479.9	9.7	0.020	PVC	PVC	3926779.29	1429065.48
	S-51	June 1997	495.90	2.64	493.3	15.0	?		2.0	4.8	488.5	14.4	478.8	9.7	0.020	PVC	PVC	3926824.07	1429045.61
	S-52†	July 1997	?	?	?	15.0	?		4.0	4.5	?	14.1	?	9.7	0.020	PVC	PVC		
	S-54	July 1998	496.98	3.07	493.9	15.0	?		2.0	10.0	483.9	15.0	478.9	5.0	0.020	PVC	PVC	3928055.37	1429680.65
Recovery	R-1	June 1986	497.64	?	496.8	9.3	?		50.0	?	?	?	?	?	NA	culvert		3926818.91	1429340.13
	R-3	Nov 1987	493.98	0.40	493.6	6.9	?		38.0	?	?	?	?	?	NA	culvert		3925550.08	1429397.48
	R-4	Nov 1987	494.93	0.77	494.2	8.6	?		50.0	?	?	?	?	?	NA	culvert		3925501.58	1429377.63
	R-5	June 1986	495.29	1.86	493.4	7.2	?		38.0	?	?	?	?	?	NA	culvert		3925824.93	1429309.40
	R-14	June 1986	493.99	1.36	492.6	6.1	?		20.0	?	?	?	?	?	NA	culvert		3927108.36	1429010.00
	R-14A	1987	494.12	1.40	492.7	10.7	?		4.0	4.0	488.7	10.7	482.0	6.7	?	ABS	ABS	3927100.21	1429016.07
	R-18	June 1987	499.67	3.71	496.0	32.8	?		10.0	7.7	488.3	32.8	463.2	25.1	?	steel	steel	3926667.15	1429608.07
	R-20R	February 2011	498.77	3.86	494.9				6.0	3.8	491.1	19.7	475.2	15.9	0.025	ss	ss	3926382.77	1429577.80
	R-21	October 1987	495.53	2.82	492.7	24.2	?		12.0	4.2	488.5	24.2	468.5	20.0	?	steel	steel	3926960.05	1429035.68
	R-22	October 1987	495.57	?	493.1	24.7	?		12.0	4.7	?	24.7	?	20.0	?	steel	steel	3927061.93	1429008.20
	R-31	Nov 1987	?	?	?	11.0	?		24.0	?	?	?	?	?	NA	culvert			
	R-32	Nov 1987	494.28	0.37	493.9	11.0	?		24.0	?	?	?	?	?	NA	culvert		3926473.43	1429438.03
	R-33	August 1988	495.77	2.53	493.2	24.6	?		12.0	7.4	485.8	24.6	468.6	17.2	?	steel	steel	3925827.95	1429332.73
	R-34	August 1988	495.15	1.82	493.3	20.8	?		12.0	0.5	492.8	20.8	472.5	20.3	?	ss	steel	3926500.01	1429393.41

Table 2-3
Well Construction Summary
North Pole Refinery
Flint Hills Resources Alaska, LLC

Well Type	Well	Install Date	Riser Elevation (feet MSL)	Riser Stickup (feet)	Ground Surface Elevation (feet MSL)	Well Depth (feet BGS)	Well Bottom Elevation (feet MSL)	Depth to Top of Permafrost (feet BGS)	Well Diameter (inches)	Well Screen							Riser Material	ALASKA STATE PLANE NAD83, ZONE 3	
										Depth to Top (feet BGS)	Top Elevation (feet MSL)	Depth to Bottom (feet BGS)	Bottom Elevation (feet MSL)	Length (feet)	Screen Slot Size (inches)	Material		NORTHING	EASTING
Recovery	R-35R	February 2011	494.74	2.01	492.7				8.0	4.0	488.7	39.0	453.7	35.0	0.008	ss	steel	3926840.14	1429455.05
	R-38	August 1988	498.65	2.74	495.9	9.8	?		24.0	?	?	?	?	?	NA	culvert		3925496.45	1429474.75
	R-39	August 1988	495.27	1.89	493.4	25.5	?		10.0	6.3	487.1	25.5	467.9	19.3	?	steel	steel	3927030.22	1429648.72
	R-40	1989	494.53	1.81	492.7	25.2	?		10.0	6.0	486.7	25.2	467.6	19.2	?	steel	steel	3927004.81	1429396.89
	R-41	July 1997	?	?	?	24.5	?		5.0	19.5	?	24.5	?	5.0	?	ss	steel		
	R-42		493.30	1.4	491.9				8.0	15.0	476.9	35.0	456.9	20.0	0.040	ss	steel	3926974.24	1428686.38

S-52† Well to be decommissioned in 2012

ss stainless steel

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Table 2-4
Sulfolane Analytical Results, Fourth Quarter 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Analysis Method					Sulfolane-EPA1625B w/Iso Dil-W
Sample	Dup	Location	Work Order	Collect Date	Sulfolane Result µg/L
ADEC Interim Groundwater Cleanup Level					25 µg/L
Onsite Wells					
Water table groundwater monitoring zone					
0-1		O-1	1119690	10/20/2011	10,400
0-3		O-3	1119690	10/19/2011	10.1J
0-4		O-4	1119690	10/19/2011	112
0-5		O-5	1119690	10/19/2011	171
0-6		O-6	1119690	10/19/2011	198
0-8		O-8	1119690	10/20/2011	13
0-12		O-12	1119690	10/19/2011	309 J
0-14		O-14	1119690	10/20/2011	<6.40
0-15		O-15	1119690	10/20/2011	<6.20
0-16		O-16	1119690	10/20/2011	<6.20
0-17		O-17	1119690	10/19/2011	346
0-18		O-18	1119690	10/20/2011	23.4
0-20		O-20	1119690	10/20/2011	1,920
0-21		O-21	1119690	10/20/2011	136 §
MW-105A		MW-105A	1119660	10/17/2011	<6.20
MW-106		MW-106	1119621	10/11/2011	<6.20
MW-109		MW-109	1119660	10/17/2011	<6.20
MW-110		MW-110	1119791	10/18/2011	1,150
MW-111		MW-111	1119621	10/11/2011	78.2
MW-113		MW-113	1119642	10/14/2011	111
MW-213	Dup	MW-113	1119642	10/14/2011	118
MW-116		MW-116	1119791	10/20/2011	28.2 JH §
MW-125		MW-125	1119791	10/18/2011	11.1
MW-127		MW-127	1119791	10/20/2011	141
MW-227	Dup	MW-127	1119791	10/20/2011	142
MW-130		MW-130	1119791	10/19/2011	1,080
			1119896	12/13/2011	1,130
MW-131		MW-131	1119791	10/18/2011	37.3
MW-132		MW-132	1119791	10/18/2011	<6.20
MW-133		MW-133	1119791	10/18/2011	<6.40
MW-135		MW-135	1119645	10/14/2011	<6.20
MW-139		MW-139	1119621	10/12/2011	312
MW-239	Dup	MW-139	1119621	10/12/2011	326
MW-141		MW-141	1119642	10/14/2011	<6.20
MW-142		MW-142	1119791	10/18/2011	489
MW-242	Dup	MW-142	1119791	10/18/2011	467
MW-143		MW-143	1119791	10/20/2011	56.4
MW-144A		MW-144A	1119642	10/14/2011	<6.20
MW-145		MW-145	1119791	10/19/2011	<6.20
MW-148A		MW-148A	1118990	10/7/2011	139
MW-248A	Dup	MW-148A	1118990	10/7/2011	128
MW-149A		MW-149A	1119633	10/13/2011	<6.20
MW-173A		MW-173A	1119621	10/12/2011	<6.20
MW-178A		MW-178A	1119642	10/14/2011	100

Table 2-4
Sulfolane Analytical Results, Fourth Quarter 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Analysis Method					Sulfolane-EPA1625B w/Iso Dil-W
Sample	Dup	Location	Work Order	Collect Date	Sulfolane Result µg/L
ADEC Interim Groundwater Cleanup Level					**25 µg/L**
MW-179A		MW-179A	1119642	10/14/2011	18.4
MW-180A		MW-180A	1119754	11/4/2011	<6.20
MW-195		MW-195A	1119661	10/15/2011	319
MW-196		MW-196	1119661	10/15/2011	<6.20
MW-301-CMT-10		MW-301-10	1119783	11/8/2011	<6.20
MW-302-CMT-10		MW-302-10	1119806	11/10/2011	55.5
MW-303-CMT-9		MW-303-9	1119808	11/11/2011	4.22J
10-55 feet below water table groundwater monitoring zone					
MW-101		MW-101	1119621	10/11/2011	35.6
MW-104		MW-104	1119621	10/11/2011	<6.20
MW-105		MW-105	1119660	10/17/2011	<6.40
MW-129		MW-129	1119791	10/19/2011	<6.20
MW-147B		MW-147B	1119621	10/11/2011	<6.20
MW-148B		MW-148B	1118990	10/7/2011	284
MW-148C		MW-148C	1118971	10/5/2011	170
MW-174A		MW-174A	1119642	10/13/2011	37.3
MW-178B		MW-178B	1119642	10/14/2011	243
MW-179B		MW-179B	1119642	10/14/2011	4.80J
MW-180B		MW-180B	1119695	10/24/2011	<6.20
MW-186B		MW-186B	1119621	10/12/2011	35.8
MW-301-CMT-20		MW-301-20	1119783	11/7/2011	<6.20
MW-601-CMT-20	Dup	MW-301-20	1119783	11/7/2011	<6.20
MW-301-CMT-30		MW-301-30	1119783	11/7/2011	<6.20
MW-301-CMT-40		MW-301-40	1119783	11/7/2011	3.24J
MW-301-CMT-50		MW-301-50	1119783	11/7/2011	5.35J
MW-301-60		MW-301-60	1119806	11/10/2011	7.02J
MW-302-CMT-20		MW-302-20	1119806	11/10/2011	76.2
MW-302-CMT-30		MW-302-30	1119806	11/10/2011	63.0
MW-302-CMT-40		MW-302-40	1119806	11/10/2011	33.2
MW-302-CMT-50		MW-302-50	1119806	11/10/2011	33.1
MW-303-CMT-19		MW-303-19	1119808	11/11/2011	123 JH
MW-303-CMT-29		MW-303-29	1119808	11/11/2011	88.5
MW-603-CMT-29	Dup	MW-303-29	1119808	11/11/2011	87.9
MW-303-CMT-39		MW-303-39	1119808	11/11/2011	47.5
MW-303-CMT-49		MW-303-49	1119808	11/11/2011	29.3
MW-303-CMT-59		MW-303-59	1119808	11/11/2011	26.8
MW-304-CMT-20		MW-304-20	1119748	11/3/2011	262
MW-304-CMT-30		MW-304-30	1119748	11/3/2011	215
MW-304-CMT-40		MW-304-40	1119748	11/3/2011	172
MW-304-CMT-50		MW-304-50	1119748	11/3/2011	24.2
MW-304-CMT-60		MW-304-60	1119748	11/3/2011	12.8
MW-305-CMT-20		MW-305-18	1119783	11/8/2011	23.5
MW-305-CMT-30		MW-305-28	1119783	11/8/2011	53.8
MW-305-CMT-40		MW-305-38	1119783	11/8/2011	10.9
MW-305-CMT-50		MW-305-48	1119783	11/8/2011	7.67J
MW-305-CMT-60		MW-305-58	1119783	11/8/2011	4.96J
MW-306-CMT-20		MW-306-20	1119806	11/9/2011	<6.20

Table 2-4
Sulfolane Analytical Results, Fourth Quarter 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Analysis Method					Sulfolane-EPA1625B w/Iso Dil-W
Sample	Dup	Location	Work Order	Collect Date	Sulfolane Result µg/L
ADEC Interim Groundwater Cleanup Level					**25 µg/L**
MW-306-CMT-30		MW-306-30	1119806	11/9/2011	<6.20
MW-606-CMT-30	Dup	MW-306-30	1119806	11/9/2011	<6.20
MW-306-CMT-40		MW-306-40	1119806	11/9/2011	<6.20
MW-306-CMT-50		MW-306-50	1119806	11/9/2011	<6.20
MW-306-CMT-60		MW-306-60	1119806	11/9/2011	<6.20
55-90 feet below water table groundwater monitoring zone					
MW-144B		MW-144B	1119642	10/13/2011	<6.20
MW-144B		MW-144B	1119755	11/4/2011	<6.32
MW-154A		MW-154A	1119642	10/13/2011	33.1
MW-154B		MW-154B	1119642	10/13/2011	35.1
MW-174B		MW-174B	1119642	10/13/2011	<6.20
MW-175		MW-175	1119791	10/19/2011	<6.20
MW-176C		MW-176C	1119791	10/19/2011	<6.20
MW-177		MW-177	1119642	10/13/2011	<6.20
MW-178C		MW-178C	1119642	10/14/2011	<6.20
MW-179C		MW-179C	1119642	10/14/2011	<6.20
MW-180C		MW-180C	1119695	10/24/2011	<6.20
MW-301		MW-301-70	1119662	10/17/2011	5.72J
MW-302-70		MW-302-70	1119806	11/10/2011	28.7
MW-302-80		MW-302-80	1119806	11/10/2011	3.39J
MW-303-70		MW-303-70	1119808	11/11/2011	19.3
MW-303-80		MW-303-80	1119808	11/11/2011	10.2
MW-304-70		MW-304-70	1119707	10/25/2011	16.8
MW-404-70	Dup	MW-304-70	1119707	10/25/2011	22.3
MW-304-80		MW-304-80	1119808	11/12/2011	6.65J
MW-305-70		MW-305-70	1119707	10/25/2011	<6.20
MW-305-80		MW-305-80	1119808	11/12/2011	<6.20
MW-605-80	Dup	MW-305-80	1119808	11/12/2011	<6.20
MW-306-70		MW-306-70	1119808	11/12/2011	<6.20
MW-306-80		MW-306-80	1119808	11/12/2011	<6.20
MW-306-100		MW-306-100	1119662	10/17/2011	<6.52
90-160 feet below water table groundwater monitoring zone					
MW-148D		MW-148D	1118971	10/5/2011	<6.20
MW-173B		MW-173B	1119621	10/11/2011	<6.20
MW-186C		MW-186C	1119791	10/19/2011	<6.20
MW-302-110		MW-302-110	1119806	11/10/2011	<6.20
MW-303-130		MW-303-130	1119808	11/11/2011	<6.20
MW-304-125		MW-304-125	1119707	10/25/2011	<6.20
MW-305A		MW-305-100	1119662	10/17/2011	4.45J
MW-306-150		MW-306-150	1119662	10/17/2011	<6.20
Offsite Wells					
Water table groundwater monitoring zone					
MW-150A		MW-150A	1119660	10/14/2011	105
MW-250A	Dup	MW-150A	1119660	10/14/2011	94.8
MW-151A		MW-151A	1119633	10/13/2011	106
MW-251A	Dup	MW-151A	1119633	10/13/2011	109

Table 2-4
Sulfolane Analytical Results, Fourth Quarter 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Analysis Method					Sulfolane-EPA1625B w/Iso Dil-W
Sample	Dup	Location	Work Order	Collect Date	Sulfolane Result µg/L
ADEC Interim Groundwater Cleanup Level					25 µg/L
MW-152A		MW-152A	1118990	10/7/2011	119
MW-153A		MW-153A	1119619	10/12/2011	66.2
MW-253A	Dup	MW-153A	1119619	10/12/2011	65.5
MW-155A		MW-155A	1119660	10/14/2011	22.2
MW-156A		MW-156A	1118979	10/6/2011	104
MW-256A	Dup	MW-156A	1118979	10/6/2011	106
MW-157		MW-157A	1119619	10/12/2011	91.3
MW-257	Dup	MW-157A	1119619	10/12/2011	89.1
MW-158A		MW-158A	1119619	10/12/2011	13.7
MW-159		MW-159A	1119619	10/11/2011	27.2
MW-161A		MW-161A	1118990	10/7/2011	138
MW-261A	Dup	MW-161A	1118990	10/7/2011	151
MW-162A		MW-162A	1118979	10/6/2011	63.6
MW-163A		MW-163A	1118979	10/6/2011	39.2
MW-164A		MW-164A	1118948	10/3/2011	106
MW-165A		MW-165A	1118979	10/5/2011	<6.20
MW-166A		MW-166A	1118979	10/4/2011	16.5
MW-167A		MW-167A	1118948	10/3/2011	3.25J
MW-168		MW-168A	1118948	10/3/2011	8.59J
MW-169A		MW-169A	1118979	10/4/2011	9.64J
MW-170A		MW-170A	1119606	10/8/2011	<6.20
MW-171A		MW-171A	1118979	10/6/2011	<6.20
MW-172A		MW-172A	1118948	10/1/2011	<6.32
MW-181A		MW-181A	1118948	10/1/2011	<6.46
MW-182A		MW-182A	1118948	10/3/2011	24.1
MW-183A		MW-183A	1119660	10/14/2011	87.1
MW-185A		MW-185A	1118948	10/1/2011	3.63J
MW-187		MW-187	1118979	10/4/2011	4.67J
MW-189A		MW-189A	1119619	10/11/2011	<6.20
MW-190A		MW-190A	1119660	10/14/2011	<6.20
MW-191A		MW-191A	1119606	10/10/2011	<6.20
MW-193A		MW-193A	1118979	10/4/2011	5.26J
MW-194A		MW-194A	1119606	10/10/2011	20.0
10-55 feet below water table groundwater monitoring zone					
MW-150B		MW-150B	1119660	10/14/2011	84.9
MW-151B		MW-151B	1119633	10/13/2011	63.2
MW-151C		MW-151C	1119660	10/14/2011	39.6
MW-152B		MW-152B	1118990	10/7/2011	114
MW-152C		MW-152C	1118971	10/5/2011	60.0
MW-153B		MW-153B	1119619	10/12/2011	33.3
MW-155B		MW-155B	1119660	10/14/2011	<6.52
MW-156B		MW-156B	1118979	10/6/2011	55.0
MW-157B		MW-157B	1119668	10/18/2011	87.3
MW-158B		MW-158B	1119619	10/12/2011	127
MW-258B	Dup	MW-158B	1119619	10/12/2011	132
MW-159B		MW-159B	1119668	10/18/2011	117
MW-161B		MW-161B	1118990	10/7/2011	316

Table 2-4
Sulfolane Analytical Results, Fourth Quarter 2011
North Pole Refinery
Flint Hills Resources Alaska, LLC

Analysis Method					Sulfolane-EPA1625B w/Iso Dil-W
Sample	Dup	Location	Work Order	Collect Date	Sulfolane Result µg/L
ADEC Interim Groundwater Cleanup Level					25 µg/L
MW-162B		MW-162B	1118979	10/6/2011	85.4
MW-163B		MW-163B	1118979	10/6/2011	64.5
MW-164B		MW-164B	1118948	10/3/2011	134
MW-164C		MW-164C	1118948	10/3/2011	133
MW-165B		MW-165B	1118979	10/5/2011	<6.20
MW-166B		MW-166B	1118979	10/4/2011	37.4
MW-167B		MW-167B	1118948	10/3/2011	7.35J
MW-168B		MW-168B	1119668	10/18/2011	11.7
MW-169C		MW-169C	1118979	10/4/2011	<6.20
MW-170D		MW-170D	1119606	10/8/2011	<6.20
MW-171B		MW-171B	1118979	10/6/2011	<6.52
MW-181B		MW-181B	1118948	10/1/2011	<6.46
MW-182B		MW-182B	1118948	10/3/2011	19.5
MW-183B		MW-183B	1119660	10/14/2011	145
MW-184		MW-184	1119660	10/14/2011	<6.20
MW-185B		MW-185B	1118948	10/1/2011	10.9
MW-188		MW-188	1118948	10/1/2011	<6.40
MW-189B		MW-189B	1119619	10/11/2011	<6.52
MW-190B		MW-190B	1119660	10/14/2011	<6.20
MW-191B		MW-191B	1119606	10/10/2011	<6.20
MW-193B		MW-193B	1118979	10/4/2011	3.91J
MW-194B		MW-194B	1119606	10/10/2011	45.4
55-90 feet below water table groundwater monitoring zone					
MW-159C		MW-159C	1119668	10/18/2011	106
MW-160B		MW-160B	1119619	10/12/2011	116
MW-260B	Dup	MW-160B	1119619	10/12/2011	118
MW-170B		MW-170B	1119606	10/8/2011	<6.20
90-160 feet below water table groundwater monitoring zone					
MW-170C		MW-170C	1119606	10/8/2011	<6.20
MW-172B		MW-172B	1118948	10/1/2011	<6.46
MW-181C		MW-181C	1119668	10/18/2011	<6.60
MW-185C		MW-185C	1119707	10/25/2011	3.65J

Notes:

µg/L	micrograms per liter
J	Estimated concentration detected above the detection limit and below the limit of quantiation (LOQ) or due to laboratory QC failures
JH	Estimated results biased high due to sulfolane-d8 surrogate failure
EPA	Environmental Protection Agency
<LOD	non-detect results are presented as <limit of detection (LOD).
Dup	Duplicate
ADEC	Alaska Department of Environmental Conservation
§	Sulfolane concentration quantified using quant ion 46, per ESI direction.

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Table 2-5
Sampled Private Wells with Depth Information
North Pole Refinery
Flint Hills Resources Alaska, LLC

YEAR BUILT	PAN	Well Log	Well Depth (feet)	Top of Permafrost (feet BGS)	Bottom of Permafrost (feet BGS)
1977	315460	Yes	45		
1998	348571	Yes	60		
1998	348554	Yes	40	1	8
1998	348589	Yes	34		
1985	315290	Yes	122	5	110
1981	333891	Yes	140	3	120
1977	315320	Yes	127	4	117
2000	318043	Yes	40		
1999	317918	Yes	40		
1999	372943	Yes	51		
1988	406333	Yes	353	30	230
1972	328383	Yes	40		
2006	348481	Yes	32		
1984	391565	Yes	120	36	105
1984	391557	Yes	150	40	150
1984	391531	Yes	205	24	205
2006	565822	Yes	40		
2005	565831	Yes	40		
1998	484067	Yes	40		
1999	348520	Yes	55	5	12
1984	375721	Yes	42		
1985	383899	Yes	50		
2001	317217	Yes	40		
2006	565521	Yes	50		
2002	519359	Yes	40		
1998	348546	Yes	33		
1975	296945	Yes	40		
1985	296937	Yes	220	20	210
1984	316679	Yes	80		
1984	316687	Yes	40		
2006	318191	Yes	40		
1984	408697	Yes	193	22	176
2006	565717	Yes	50		
1979	294501	Yes	36		
1998	348716	No	40		
2006	565636	Yes	40		
1984	391361	Yes	133	19	133
1984	391344	Yes	202	7	202
1987	391336	Yes	320	5	195
2006	565709	Yes	40		
1996	315192	Yes	89	22	70
1984	395340	Yes	218	65	215
2000	297046	Yes	40		
1985	303917	Yes	223	11	217
2003	317497	Yes	40		
2005	317969	Yes	40		
1984	379883	No	33		
1984	395099	No	74		
1985	406384	Yes	33		

Table 2-5
Sampled Private Wells with Depth Information
North Pole Refinery
Flint Hills Resources Alaska, LLC

YEAR BUILT	PAN	Well Log	Well Depth (feet)	Top of Permafrost (feet BGS)	Bottom of Permafrost (feet BGS)
1984	381039	Yes	42		
1981	333883	Yes	196	12	180
2006	565695	Yes	40		
1983	347531	No	35		
1984	395218	Yes	70	32	70
2005	304034	Yes	54		
1964	535885	Yes	40		
2001	499897	Yes	40		
2001	333778	Yes	236	8	230
1982	333905	Yes	60		
1977	296449	Yes	200		
1980	290670	Yes	40		
1987	297135	Yes	40		
2005	318205	Yes	40		
2006	565512	Yes	50		
1984	391409	Yes	255	19	146
1985	429929	Yes	305	8	228
1985	333794	Yes	40	27	40
1985	333786	Yes	42	23	38
1984	399248	Yes	65		
0	445657	Yes	215	5	205
2006	565849	Yes	40		
2004	429911.1	Yes	40		
2006	565652	Yes	60		
2005	565661	Yes	40		
2003	317926	Yes	40		
1967	406309	Yes	21		
2002	460800	Yes	40		
2003	317713	Yes	40		
1984	375730	Yes	42		
1983	375748	Yes	50		
1999	348538	Yes	55	8	13
1984	302082	Yes	105	20	103
1984	395200	Yes	236	55	230
1984	395196	Yes	295	3	245
1998	348856	Yes	55		
0	395251	Yes	38	12	27
1998	348864	Yes	40		
1999	507075	Yes	40		
1984	391492	Yes	100		
1987	348619	Yes	42		
2006	519286	Yes	40		
1994	348503	Yes	60		
2005	565725	Yes	40		
2005	565733	Yes	50		
2005	565741	Yes	40		
2007	579581	Yes	220	12	200
1987	315249	Yes	40		
1998	429881.2	Yes	40		

Table 2-5
Sampled Private Wells with Depth Information
North Pole Refinery
Flint Hills Resources Alaska, LLC

YEAR BUILT	PAN	Well Log	Well Depth (feet)	Top of Permafrost (feet BGS)	Bottom of Permafrost (feet BGS)
0	290190	Yes	238	6	215
1983	297062	Yes	40		
2006	581593	Yes	40		
2006	581666	Yes	40		
1998	429881.1	Yes	75	8	65
2004	429911.2	Yes	40		
2004	429911.3	Yes	115	10	92
1983	375586	Yes	76.0		
1983	375594	Yes	53.0		
1972	513431	No	26.5		
2000	315206	Yes	98.0	25	90
1982	373834	No	20.0		
1985	296775	No	160.0		
1982	296783	Yes	186.0		
1976	296635	No	49.0		
1980	278912	No	30.0		
1985	296813	Yes	40.0	34	40
1982	296830	Yes	205.0		
1983	348473	No	35.6		
1983	375608	Yes	42.0		
1982	296805	Yes	200.0		
1983	375578	Yes	63.0		
1979	296759	No	63.0		
1979	296767	No	63.0		
1976	296724	No	40.0		
1982	296589	No	220.0		
1993	130427	No	32.0		
1985	296732	Yes	41.0		
1983	348465	Yes	40.0		
1986	427063	No	220.0		
1997	296856	Yes	218.0		
1996	348902	Yes	40.0		
1986	296571	No	48.0		
1979	115525	No	40.0		
1978	278963	No	35.0		
2002	303836	No	30.0		
1998	513423	No	45.0		
1977	296741	Yes	230.0		
1984	375551	Yes	48.0		
1983	375543	Yes	53.0		
1997	401871	No	30.0		
1981	113964	No	30.0		
1985	383881	No	45.0		
1984	348155	Yes	40.0		
1986	383830	Yes	62.0		
1983	375560	Yes	42.0		
1972	403971	No	35.0		
1978	279111	No	30.5		
1984	277045	Yes	60.0	N/A	

Table 2-5
Sampled Private Wells with Depth Information
North Pole Refinery
Flint Hills Resources Alaska, LLC

YEAR BUILT	PAN	Well Log	Well Depth (feet)	Top of Permafrost (feet BGS)	Bottom of Permafrost (feet BGS)
1986	383848	Yes	40.0		
1984	295884	No	35.0		
1976	296643	No	45.0		
1979	113921	No	30.0		
2004	348724	Yes	40.0		
1976	296163	Yes	40.0		
1997	401951	No	35.0		
1976	288845	No	30.0		
1972	424391	Yes	51.0	3	20
2004	348651	Yes	40.0		
1983	375641	Yes	42.0		
1983	375632	Yes	42.0		
1984	383856	No	40.0		
1984	375624	Yes	40.0		
1983	347400	No	33.0		
1984	375659	Yes	65.0		
1983	375667	No	42.0		
1983	375675	Yes	40.0		
1984	383864	No	40.0		
1983	375683	Yes	42.0		
1985	383872	No	34.0		
1983	348449	No	40.0		
1984	383759	Yes	51.0		
1976	296716	No	40.0		
2000	348732	Yes	40.0		
1984	346110	No	32.0		
1980	296627	No	57.0		
1982	296601	No	158.0		
1984	296597	No	170.0		

Table 3-1 Ground Water Drinking Water Population

Distance Ring (miles)	Number of Wells	Well Population	Total Population per Distance Ring
0 - ¼	Domestic - 7	18.76	18.76
¼ - ½	Domestic - 20	53.6	53.6
½ - 1	Domestic - 30	80.4	80.4
1 – 2	Domestic - 165	442.2	4838.2
	Municipal - 2	4,396[a]	
2 – 3	Domestic - 405	1,085.4	1,085.4
3 – 4	Domestic - 87	233.16	233.16
TOTAL			**6,309.32**

Sources: DOC 2001; WELTS 2012; ADEC 2012.

Note: Well population was estimated based on the average number of per persons per household for the borough in which the well is located. The average population per household for the Fairbanks North Star Borough is 2.68.

[a] Population includes residents, workers, and students/teachers

Table 3-2 Sport Catch Data

Species	Number Harvested	Average Pound per Fish	Pounds Harvested
Burbot (*Lota lota*)	346 x 11% = 38.06	5	190.3
Arctic Grayling (*Thymallus arcticus*)	52 x 11% = 5.72	3	17.16
Total			**207.46**

Source: ADFG 2010; Wydoski 2003

Table 3-3 Subsistence Catch Data

Species	Number Harvested	Average Pound per Fish	Pounds Harvested
Chinook Salmon (Winter) (*Oncorhynchus tshawytscha*)	126 x 22% = 27.72	22	609.84
Chinook Salmon (Summer) (*Oncorhynchus tshawytscha*)	138 x 22% = 30.36	22	667.92
Chum Salmon (Fall) (*Oncorhynchus keta*)	181 x 22% = 39.82	9	358.38
Coho Salmon (*Oncorhynchus kisutch*)	50 x 22% = 11.00	10	110.00
Total			**1,746.14**

Source: ADFG 2010; Wydoski 2003

Table 3-4 Population and Wetland Acreage by Distance Ring

Distance (miles)	Resident Population[a]	Student/ Teacher Population	Worker Population	Wetland Acreage
On a source	0	0	0	0
0 – ¼	25	0	500	0
¼ – ½	82	0	0	43.44
½ – 1	1,095	1,539	0	60.75
1 – 2	2,481	788	0	118.61
2 – 3	2,235	95	0	860.26
3 – 4	2,058		0	991.08
TOTAL		**10,898**		**2,074.14**

Source: Maguire 2010; NCCES 2010

Figures

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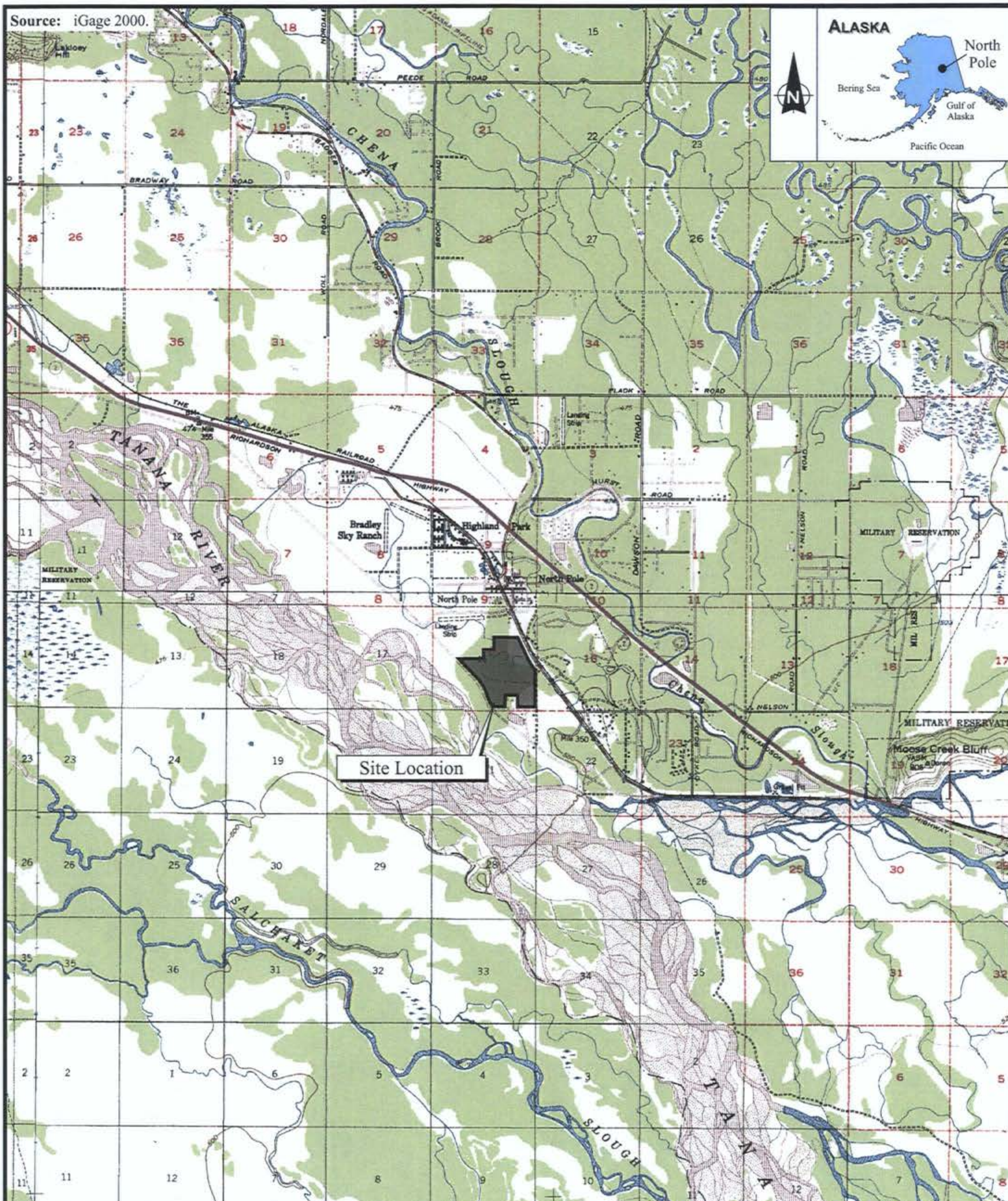

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Seattle, Washington

FLINT HILLS RESOURCES' NORTH POLE REFINERY
North Pole, Alaska

Figure 1-1

SITE LOCATION MAP

0 .5 1
Approximate Scale in Miles

Date: 5-7-12

Drawn by: AES

10:START-3\12040001\fig 1-1

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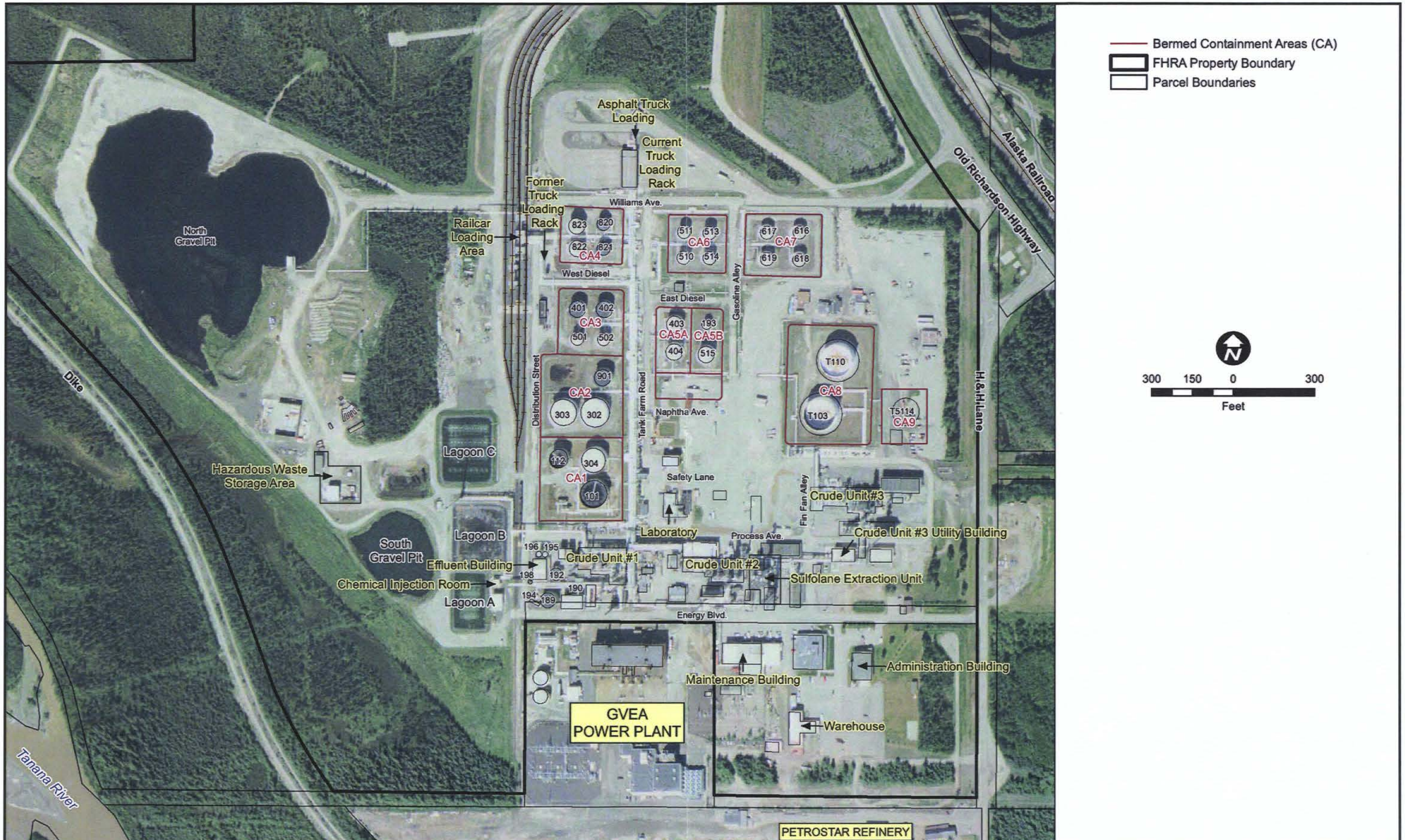

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Source: Barr Engineering Company 2012.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-1
SITE FEATURES

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-1

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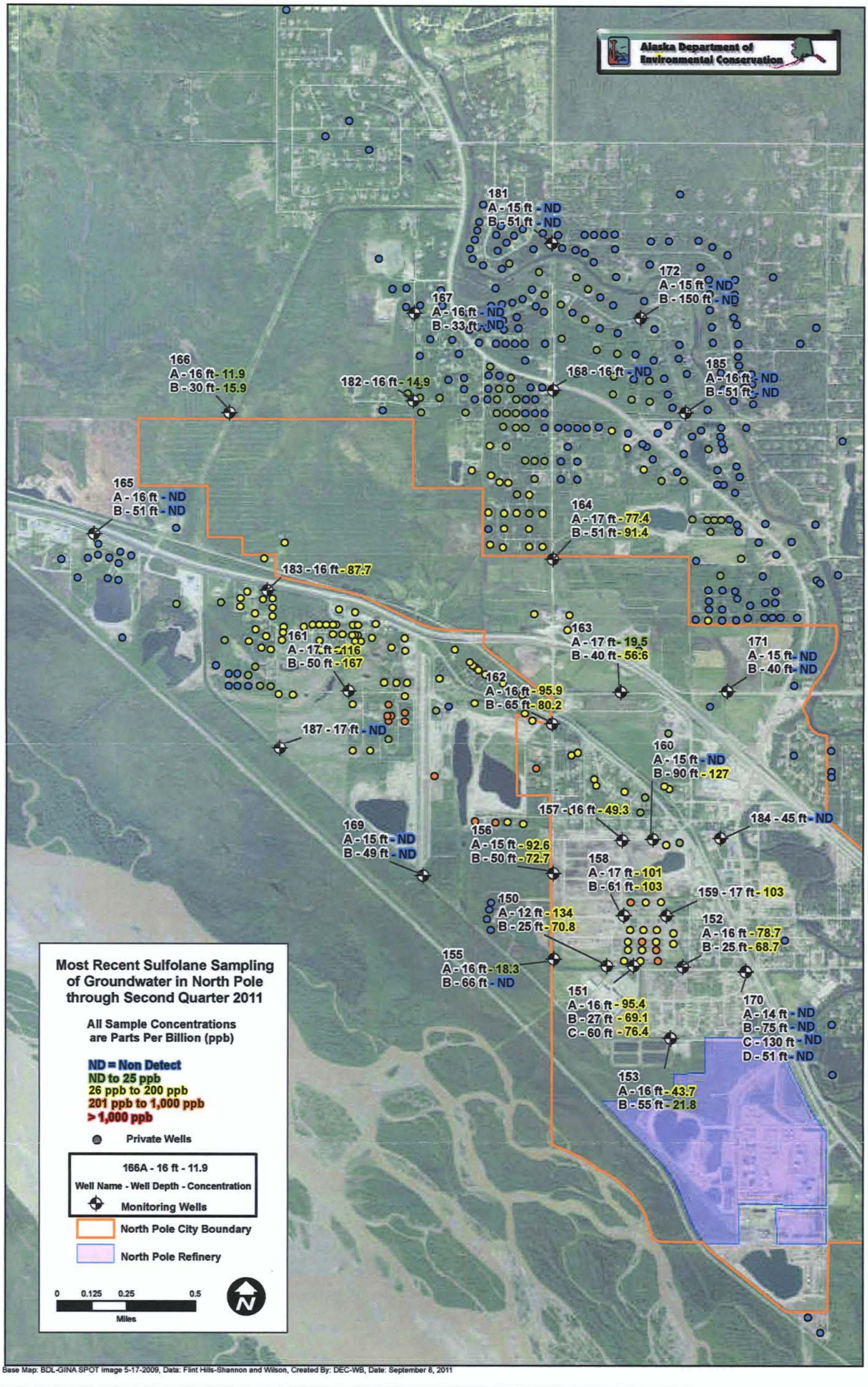

Base Map: BDL-GINA SPOT Image 5-17-2009, Data: Flint Hills-Shannon and Wilson, Created By: DEC-WB, Date: September 8, 2011

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-2 MOST RECENT SULFOLANE SAMPLING OF GROUND WATER IN NORTH POLE THROUGH SECOND QUARTER 2011		
	Source: Shannon & Wilson, Inc. 2001.	Date: 5/7/12	Drawn by: AES	10:START-3\12040001\fig 2-2

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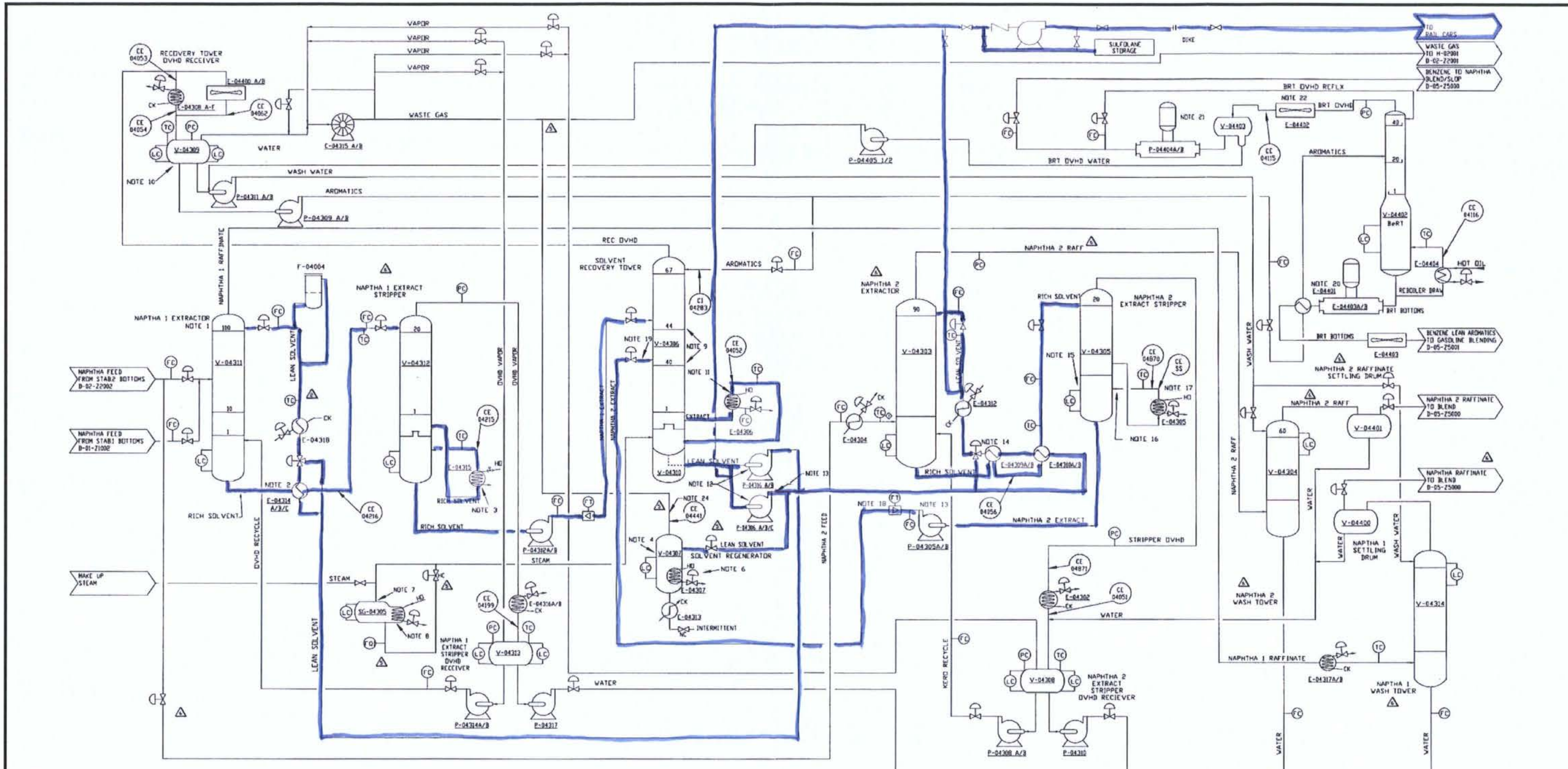

NOTES:

1 -"BLACK SAND" FOULING AFTER ACID WASH 4/01, TOP TRAY

2 -REPLACED E-04314A 4/01 DUE TO TUBE SIDE THINNING AT TUBE SHEET OF THE INITIAL PASS.

3 -BUNDLE FAILURE/REPLACEMENT, DUE TO EROSION/CORROSION
REPLACED WITH 2205 DUPLEX SS.
-MODERATE SHELL LOSSES IN UPPER THIRD

4 -REGULAR TRAY UPSETS

5 -SHELL CORROSION AT WELDS IN LOWER HALF

6 -BUNDLE CORROSION & MECHANICAL DAMAGE CAUSED BY TRAY UPSETS

7 -NOZZLE REPLACED DUE TO CORROSION

8 -BUNDLE REPLACED DUE TO CORROSION

9 -TRAY DAMAGE DUE TO FEED VELOCITY - MODIFIED SHELL DAMAGE FROM VELOCITY EFFECTS

10 -SHELL PITTING

11 -SHELL DAMAGE DUE TO EROSION/CORROSION MULTIPLE BUNDLE FAILURES, BUNDLE NOW 2205 DUPLEX SS

12 -CASES CHANGED TO ALLOY DUE TO EROSION/CORROSION

13 -SOME EROSION/CORROSION DAMAGE

14 -BUNDLES REPLACED
SHELL & TUBE SIDE CORROSION
SHELLS OK

15 -5'X5' SHELL REPLACEMENT DUE TO EROSION/CORROSION

16 -EROSION/CORROSION AT SPECTACLE BLIND AREA BETWEEN VESSEL & PIPE

17 -SHELL DAMAGE DUE TO EROSION/CORROSION MULTIPLE BUNDLE FAILURES, BUNDLE NOW 2205 DUPLEX SS

18 -PIPE FAILURE DUE TO EROSION/CORROSION REPLACED TRANSMITTER

19 -CV & DOWN STREAM PIPING FAILURE DUE TO EROSION/CORROSION

20 -HEAVY FOULING TUBE SIDE IN PAST.
BUNDLE REPLACED DUE TO CORROSION ON TUBE-SIDE

21 -SIGNIFICANT PITTING CORROSION PRIOR TO CHEMICAL
INJECTION PROGRAM AT CI-04117&8

22 -FAILED TUBE DUE TO CORROSION.
REPLACED COOLER BUNDLE.

23 -SEE DRAWING D-04-24004 FOR PROCESS EQUIPMENT.

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	**Source:** Barr Engineering Company 2012.	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-3 EXTRACTION UNIT COMPLETE SYSTEM PROCESS FLOW DIAGRAM
			Date: 5/15/12 · Drawn by: AES · 10:START-3\12040001\fig 2-3

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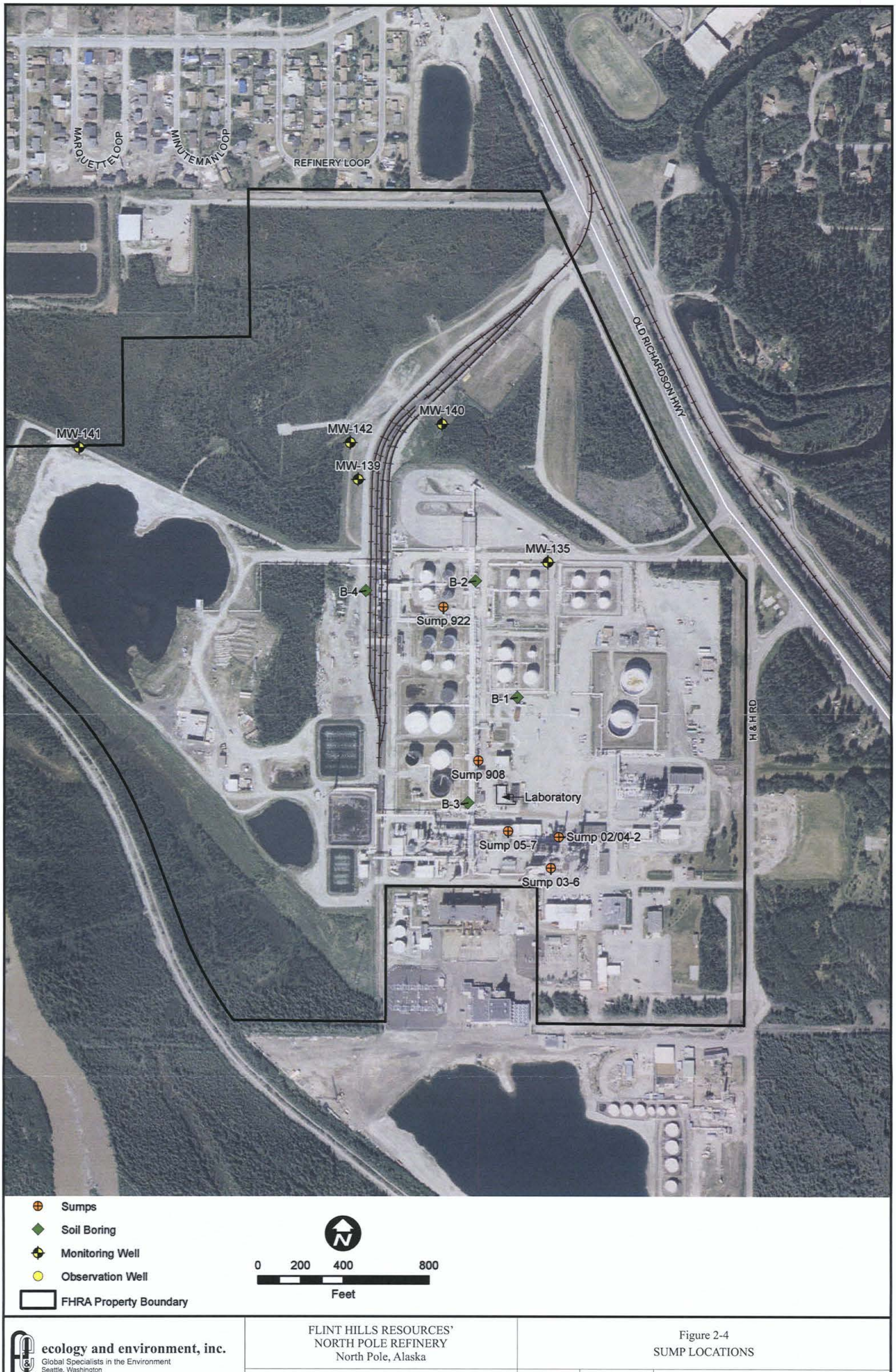

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-4 SUMP LOCATIONS		
	Source: Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES	10:START-3\12040001\fig 2-4

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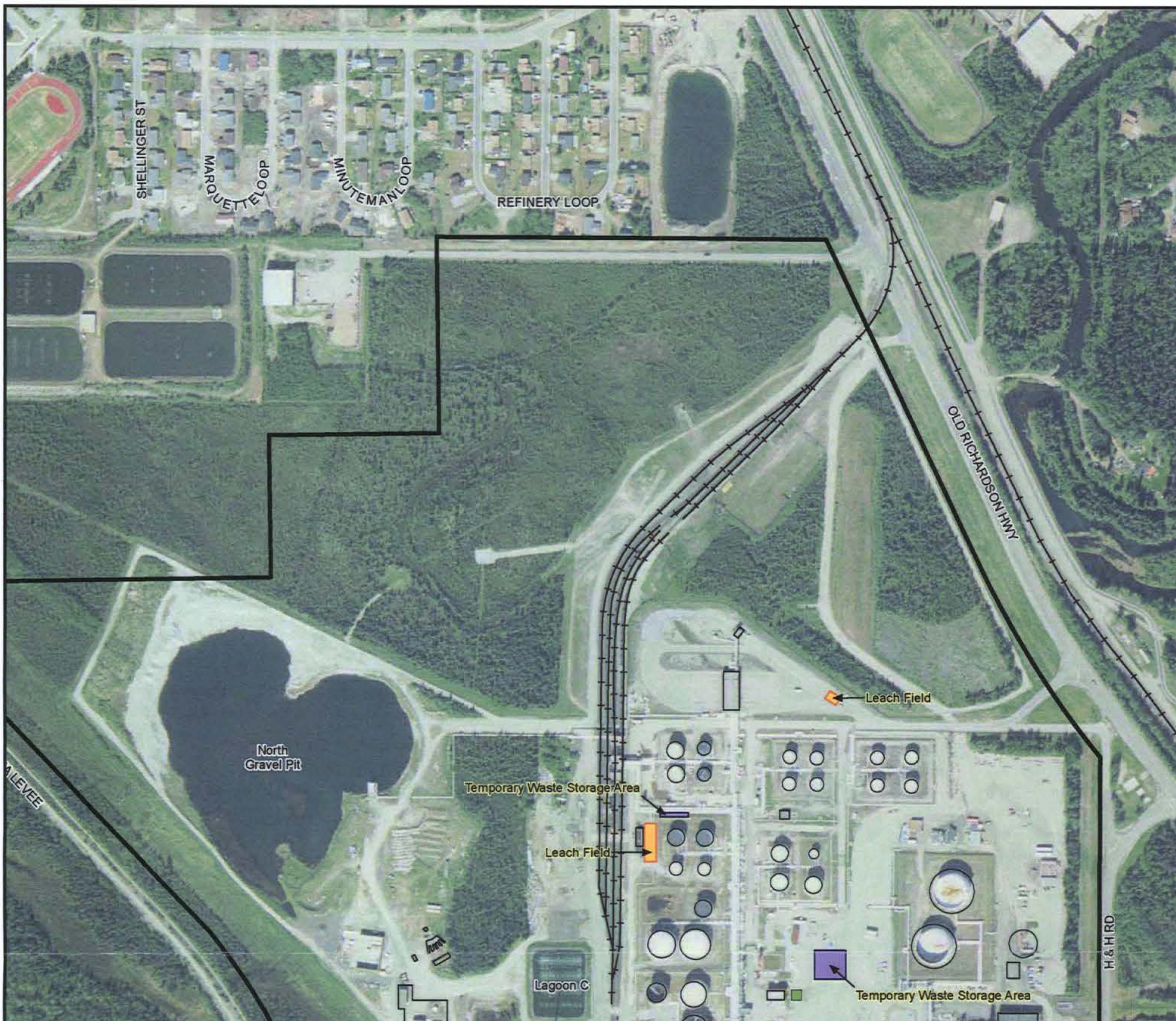

UST

Domestic Wastewater Leach Field

Temporary Waste Storage Area

FHRA Property Boundary

Note: Additional domestic wastewater leach fields are present at the Firehouse and Construction Office (abandoned).

N

0 200 400 800

Feet

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	Source: Barr Engineering Company 2012.	Date: 5/7/12 · Drawn by: AES · 10:START-3\12040001\fig 2-5

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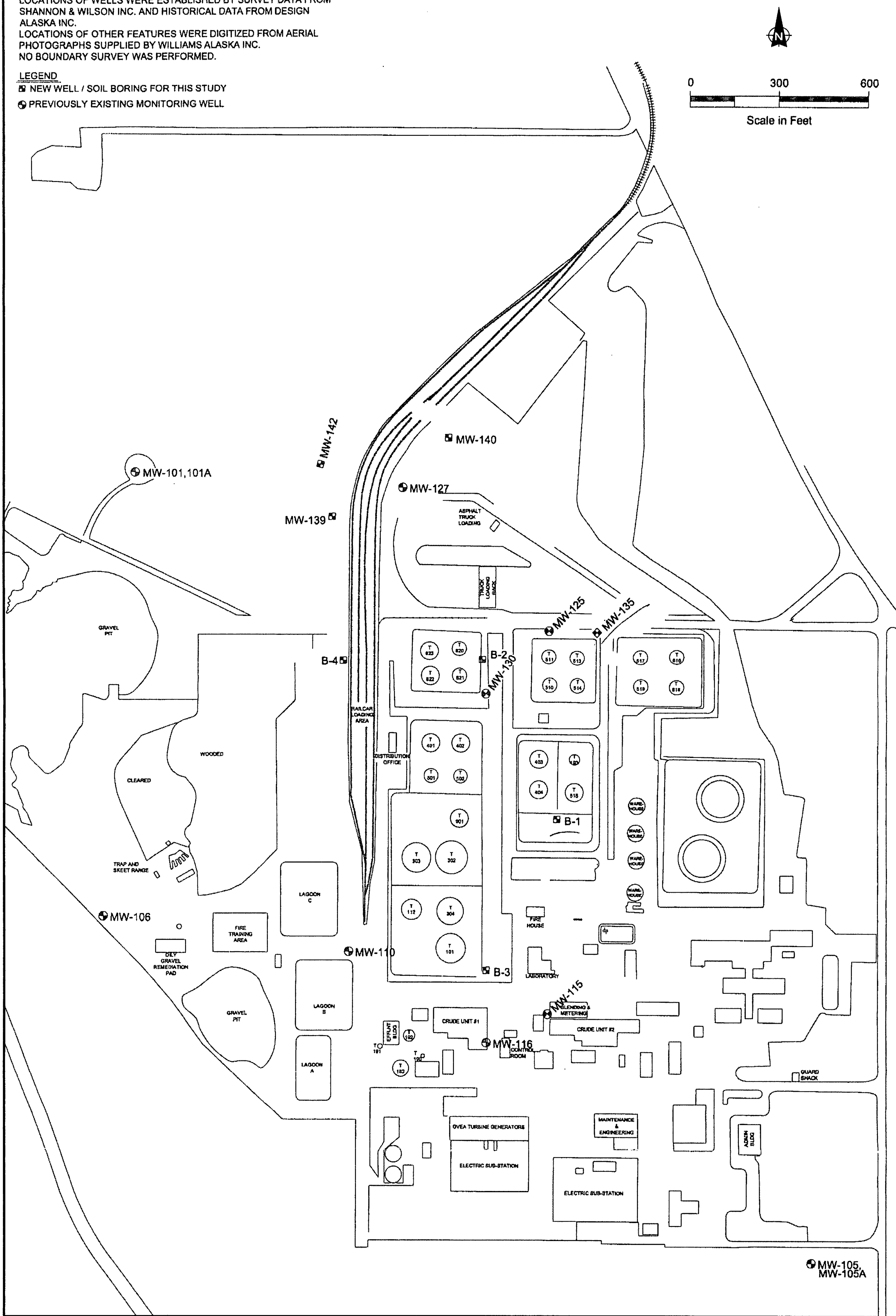
NOTE:
LOCATIONS OF WELLS WERE ESTABLISHED BY SURVEY DATA FROM SHANNON & WILSON INC. AND HISTORICAL DATA FROM DESIGN ALASKA INC.
LOCATIONS OF OTHER FEATURES WERE DIGITIZED FROM AERIAL PHOTOGRAPHS SUPPLIED BY WILLIAMS ALASKA INC.
NO BOUNDARY SURVEY WAS PERFORMED.

LEGEND
NEW WELL / SOIL BORING FOR THIS STUDY
PREVIOUSLY EXISTING MONITORING WELL



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FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-6 2001 CONTAMINANT CHARACTERIZATION STUDY SAMPLE LOCATIONS		
Source: Shannon & Wilson, Inc. 2001.	Date: 5/7/12	Drawn by: AES	10:START-3\12040001\fig 2-6

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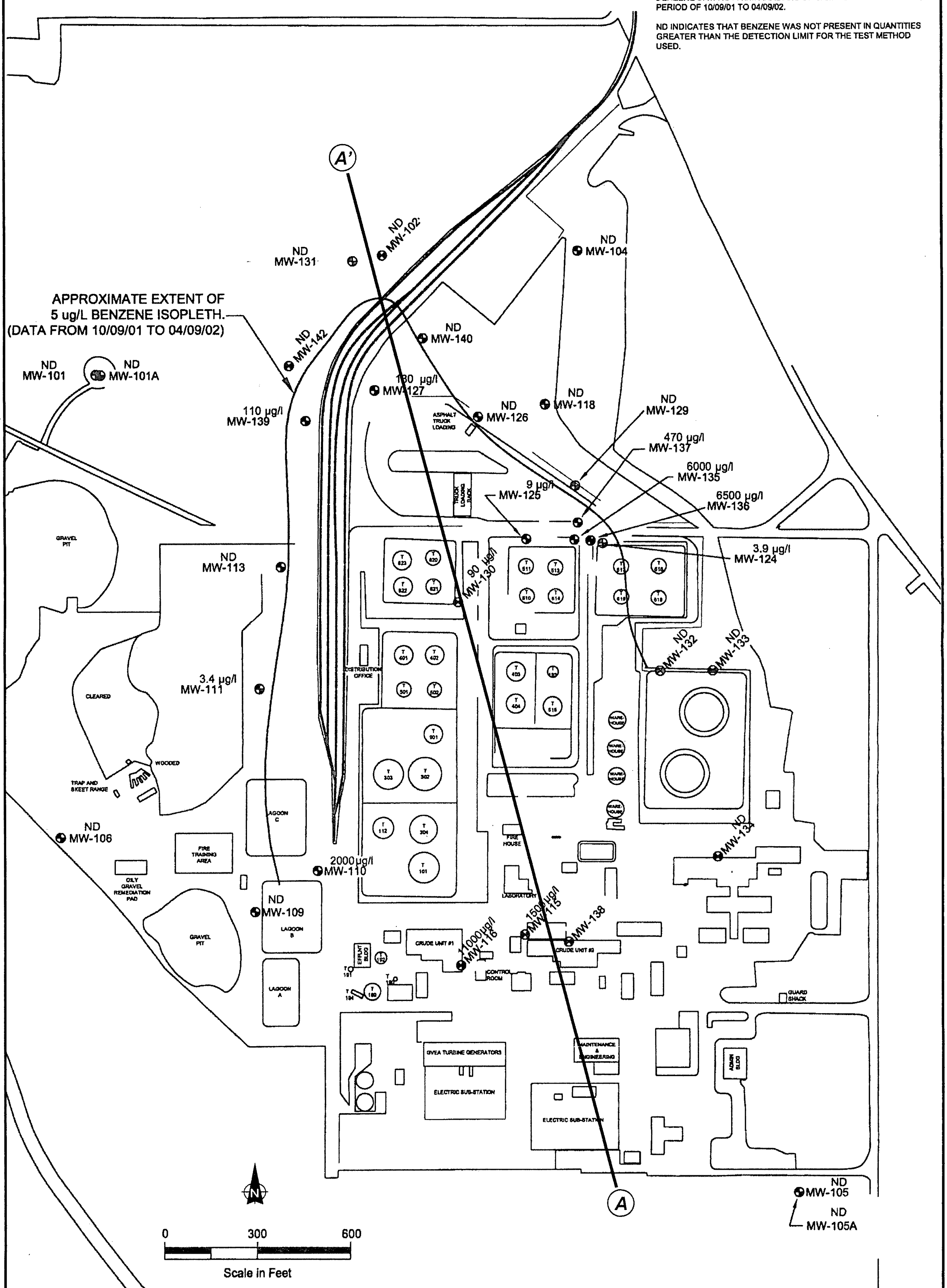
NOTE:
LOCATIONS OF WELLS WERE ESTABLISHED BY SURVEY DATA FROM SHANNON & WILSON INC. AND HISTORICAL DATA FROM DESIGN ALASKA INC.
LOCATIONS OF OTHER FEATURES WERE DIGITIZED FROM AERIAL PHOTOGRAPHS SUPPLIED BY WILLIAMS ALASKA INC.
NO BOUNDARY SURVEY WAS PERFORMED.

BENZENE DATA IS FROM ANALYSIS OF SAMPLES TAKEN DURING THE PERIOD OF 10/09/01 TO 04/09/02.

ND INDICATES THAT BENZENE WAS NOT PRESENT IN QUANTITIES GREATER THAN THE DETECTION LIMIT FOR THE TEST METHOD USED.



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FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-7
2001/2002 BENZENE DATA AND ESTIMATED PLUME EXTENT

Source: Shannon & Wilson, Inc. 2002.

Date: 5/7/12

Drawn by: AES

10:START-3\12040001\fig 2-7

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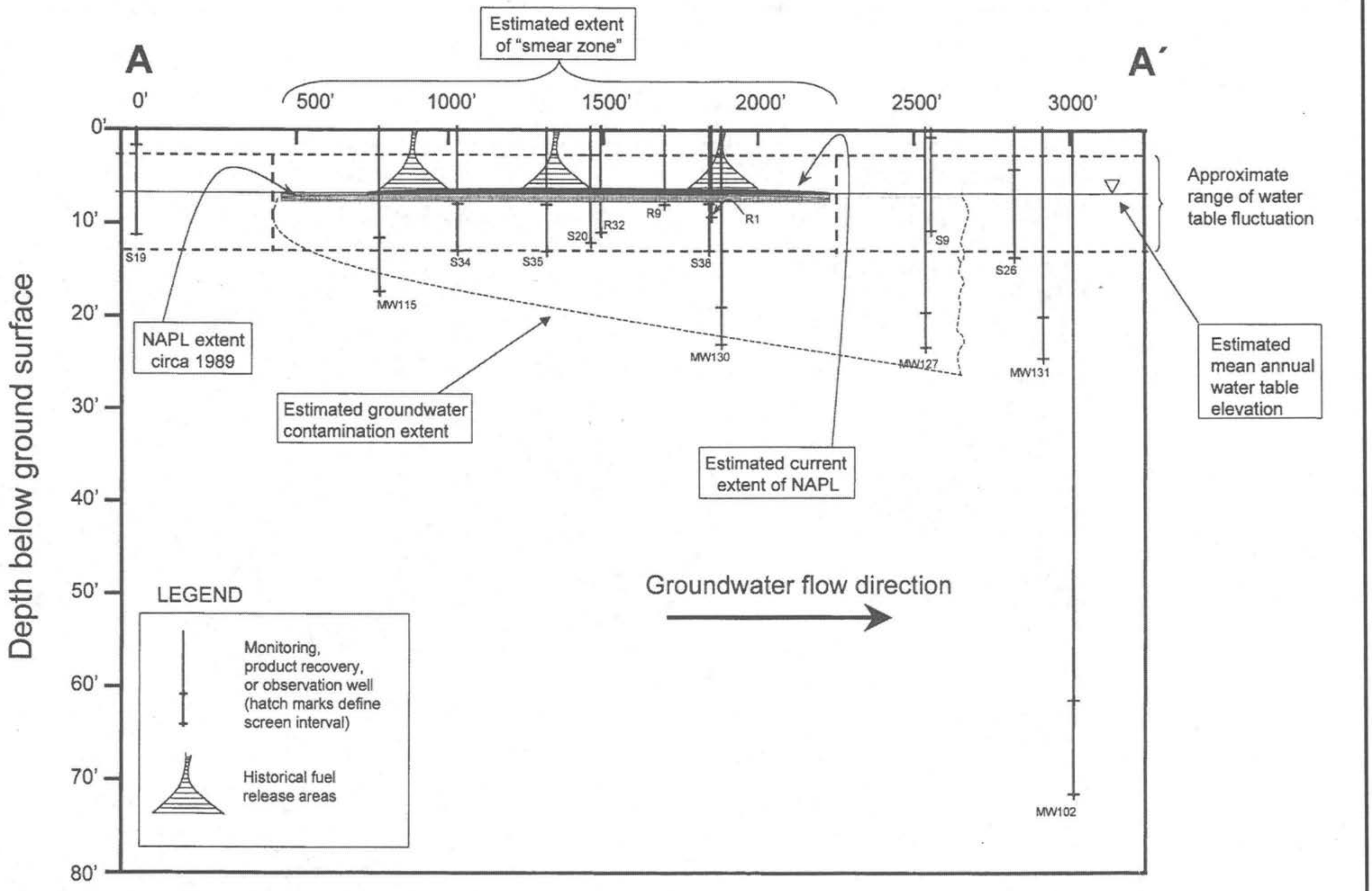

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FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

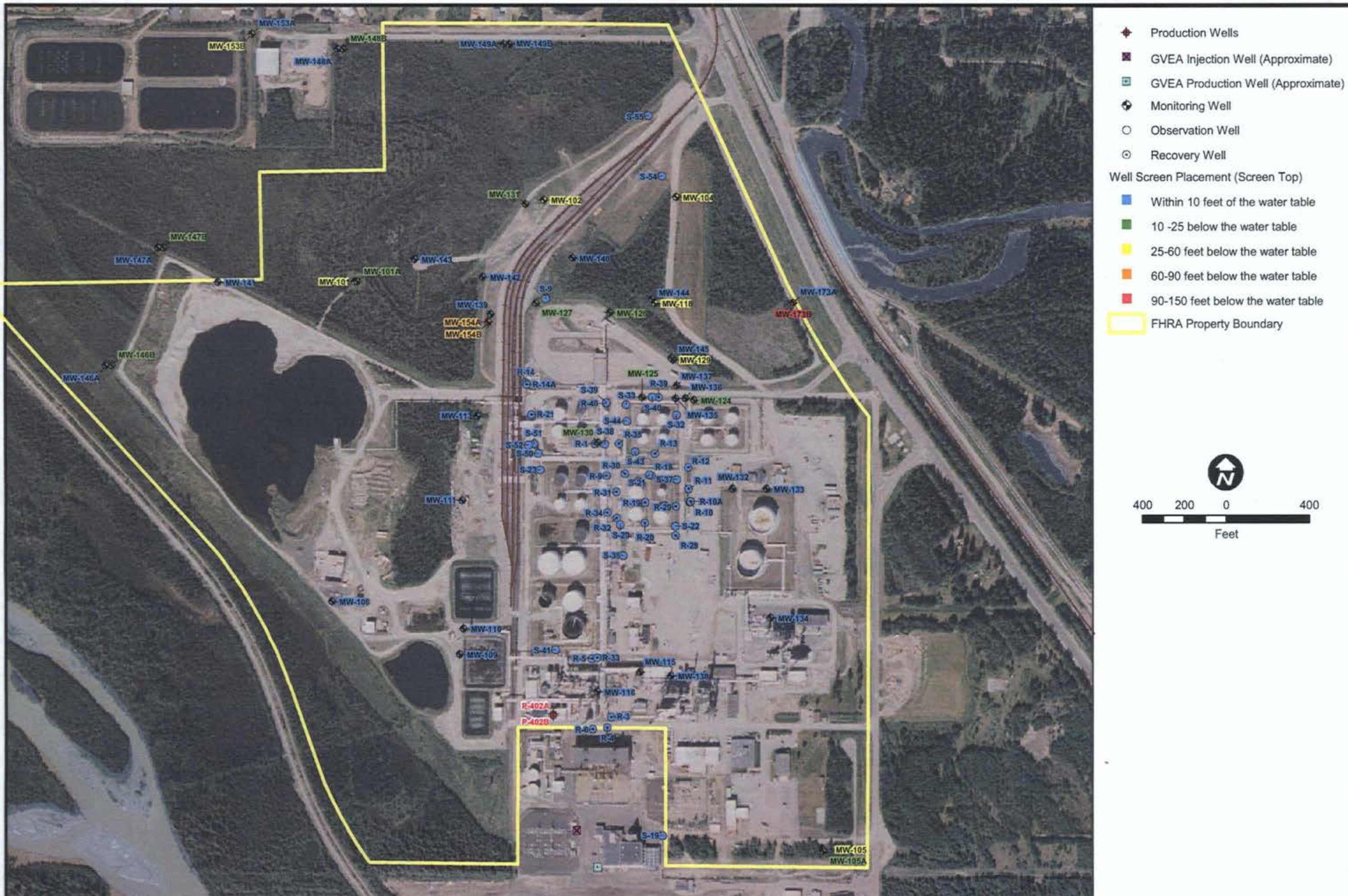
Figure 2-8
CONCEPTUAL SITE MODEL
CROSS-SECTION ALONG TRANSECT A - A' AT REFINERY

Source: Shannon & Wilson, Inc. 2002.

Date: 5/7/12

Drawn by: AES

10:START-3\12040001\fig 2-8



FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-9 2010 ON-SITE WELL NETWORK		
Source: Barr Engineering Company 2010.	Date: 9/21/10	Drawn by: AES	10:START-3\10060005\fig 2-9

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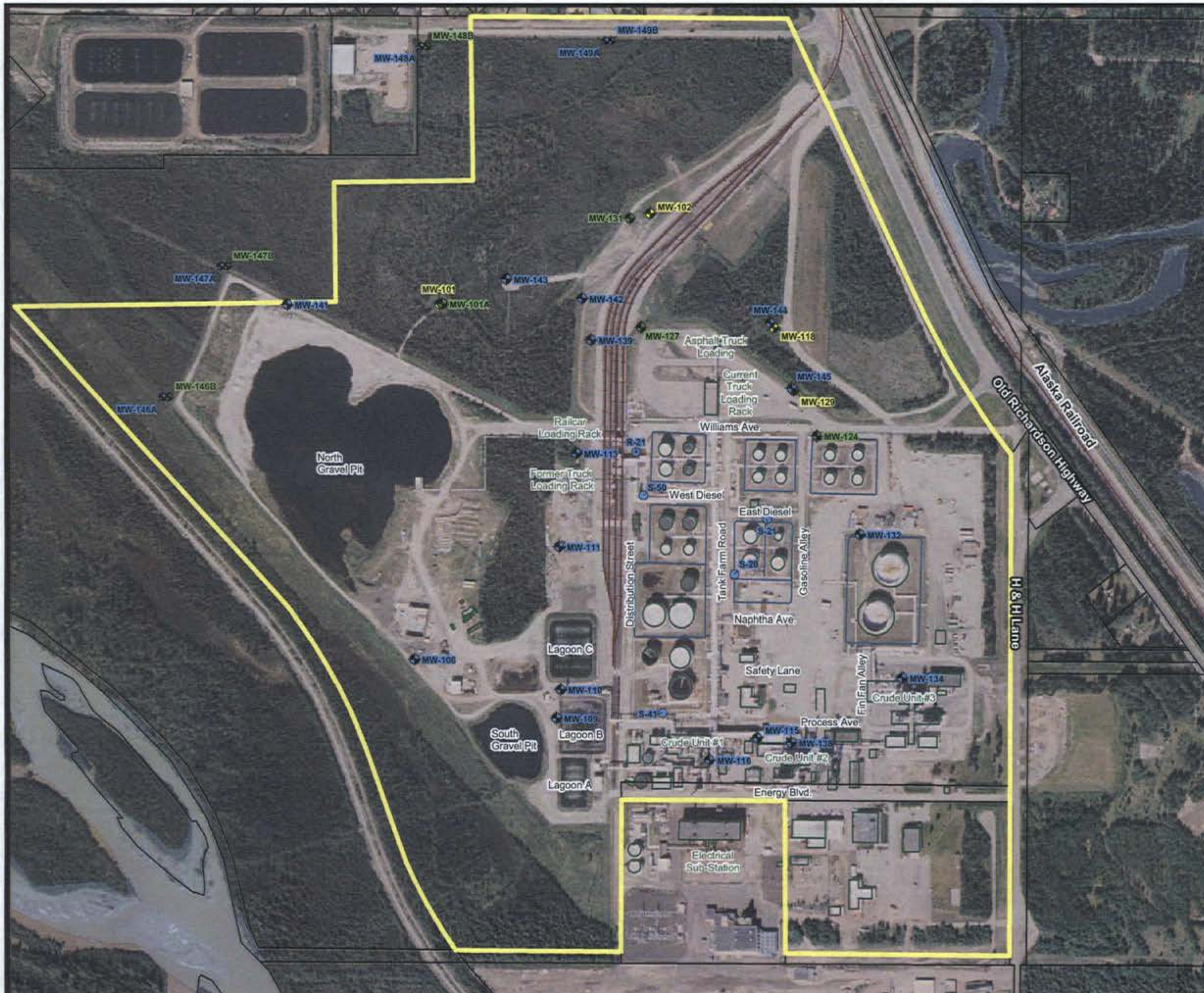
NORTH POLE REFINERY
North Pole, Alaska

Source: Barr Engineering Company 2010.

Figure 2-10
NEW (2010) DELINEATION WELLS

Date:	Drawn by:	
9/21/10	AES	10:START-3\10060005\fig 2-10



Monitoring Well
Observation Well
Recovery Well
Well Screen Placement
Within 10 Feet of the Water Table
10-25 Feet Below Water Table
25-60 Feet Below Water Table
60-90 Feet Below Water Table
90-150 Feet Below Water Table
FHRA Property Boundary
Parcel Boundaries

Sampling Frequency

Monthly	Quarterly	Semi-Annually
MW-101A	MW-101	MW-102
MW-110	MW-109	MW-106
MW-131	MW-113	MW-111
MW-138	MW-115	MW-118
MW-139	MW-116	MW-124
MW-142	MW-141	MW-127
MW-143	MW-146A	MW-129
MW-148A	MW-146B	MW-132
MW-148B	MW-147A	MW-134
MW-149A	MW-147B	MW-144
MW-149B	R-21	MW-145
S-50	S-21	S-20
		S-41

N

400 200 0 400
Feet

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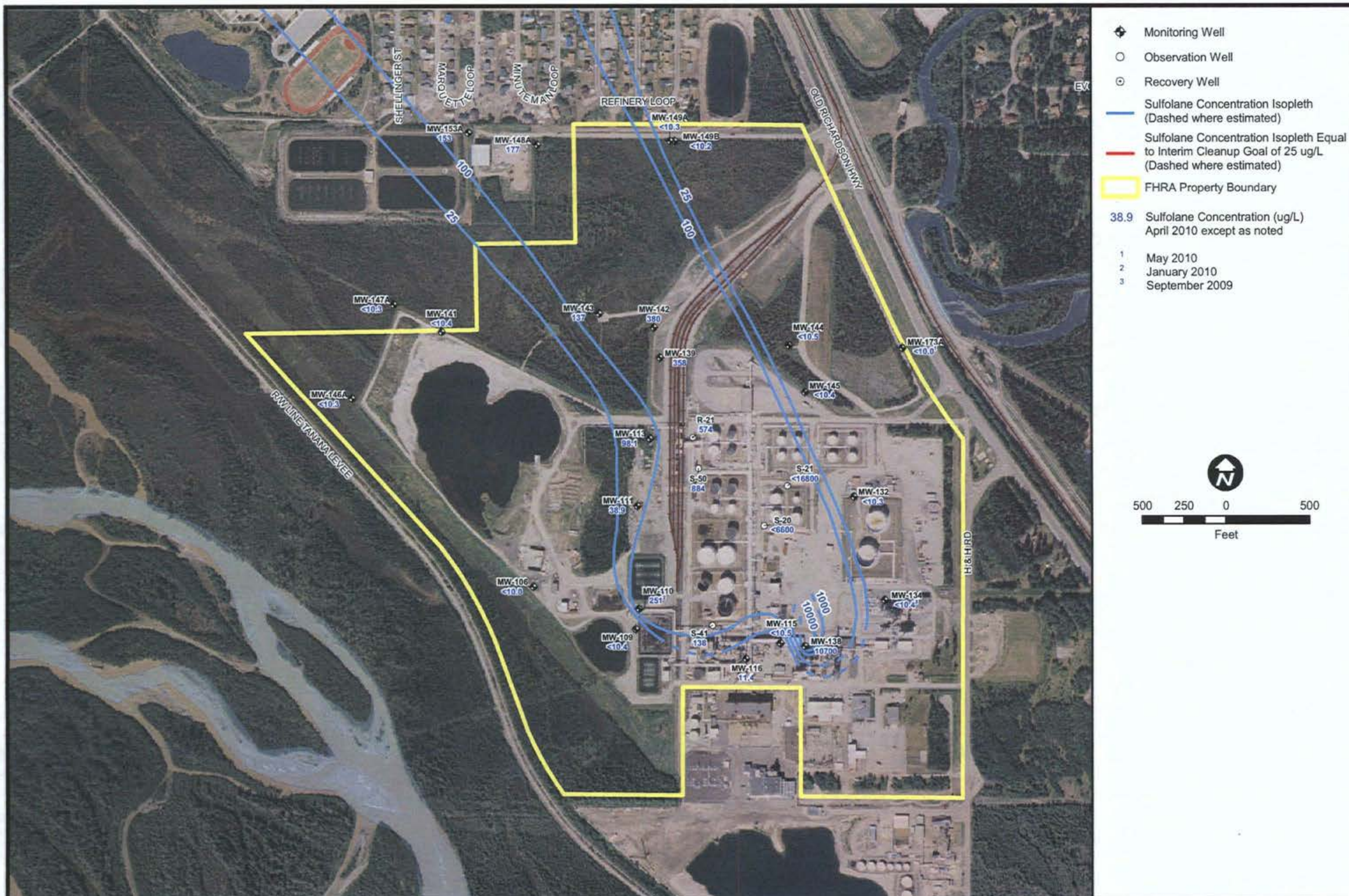
FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Source: Barr Engineering Company 2010.

Figure 2-11
ON SITE SULFOLANE MONITORING NETWORK

Date:	Drawn by:	
9/21/10	AES	10:START-3\10060005\fig 2-11



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FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Source: Barr Engineering Company 2010.

Figure 2-12
ON- AND OFF-SITE SULFOLANE CONCENTRATIONS WITHIN 10-FEET OF WATER TABLE

Date:	Drawn by:	
9/21/10	AES	10:START-3\10060005\fig 2-12

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Monitoring Well

Observation Well

Recovery Well

Sulfolane Concentration Isopleth (Dashed where estimated)

FHRA Property Boundary

181 Sulfolane Concentration (ug/L) April 2010, except as noted

1 Data from March 2010

2 Data from February 2010

N

2,000 1,000 0 2,000

Feet

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Seattle, Washington

Source: Barr Engineering Company 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-13

SULFOLANE CONCENTRATIONS IN GROUND WATER WITHIN 10 FEET OF WATER TABLE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-13

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Source: Barr Engineering Company 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-14

SULFOLANE CONCENTRATIONS IN GROUNDWATER
15-55 FEET BELOW THE WATER TABLE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-14

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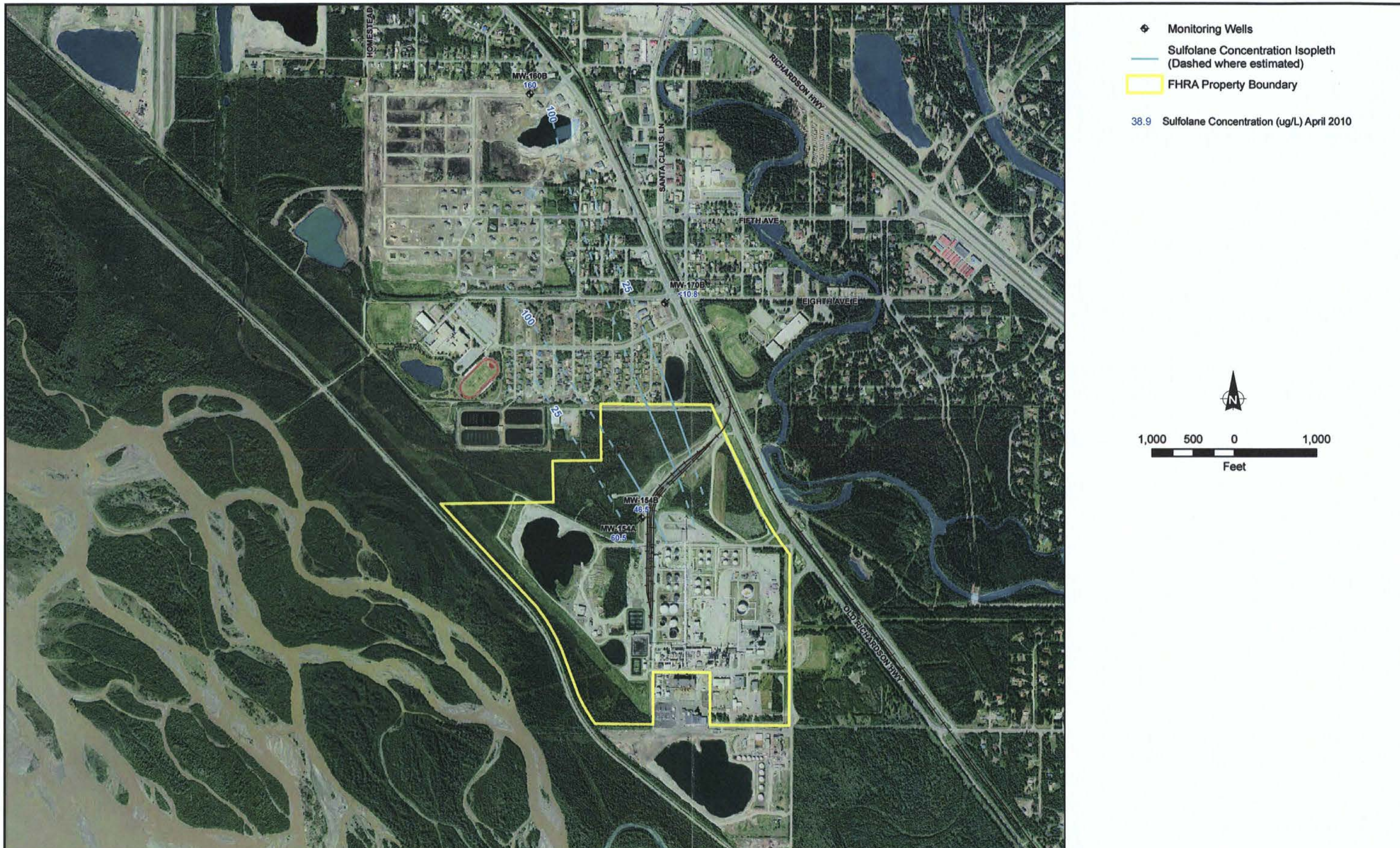

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Global Specialists in the Environment
Seattle, Washington

Source: Barr Engineering Company 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-15
SULFOLANE CONCENTRATIONS IN GROUNDWATER
55-90 FEET BELOW THE WATER TABLE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-15

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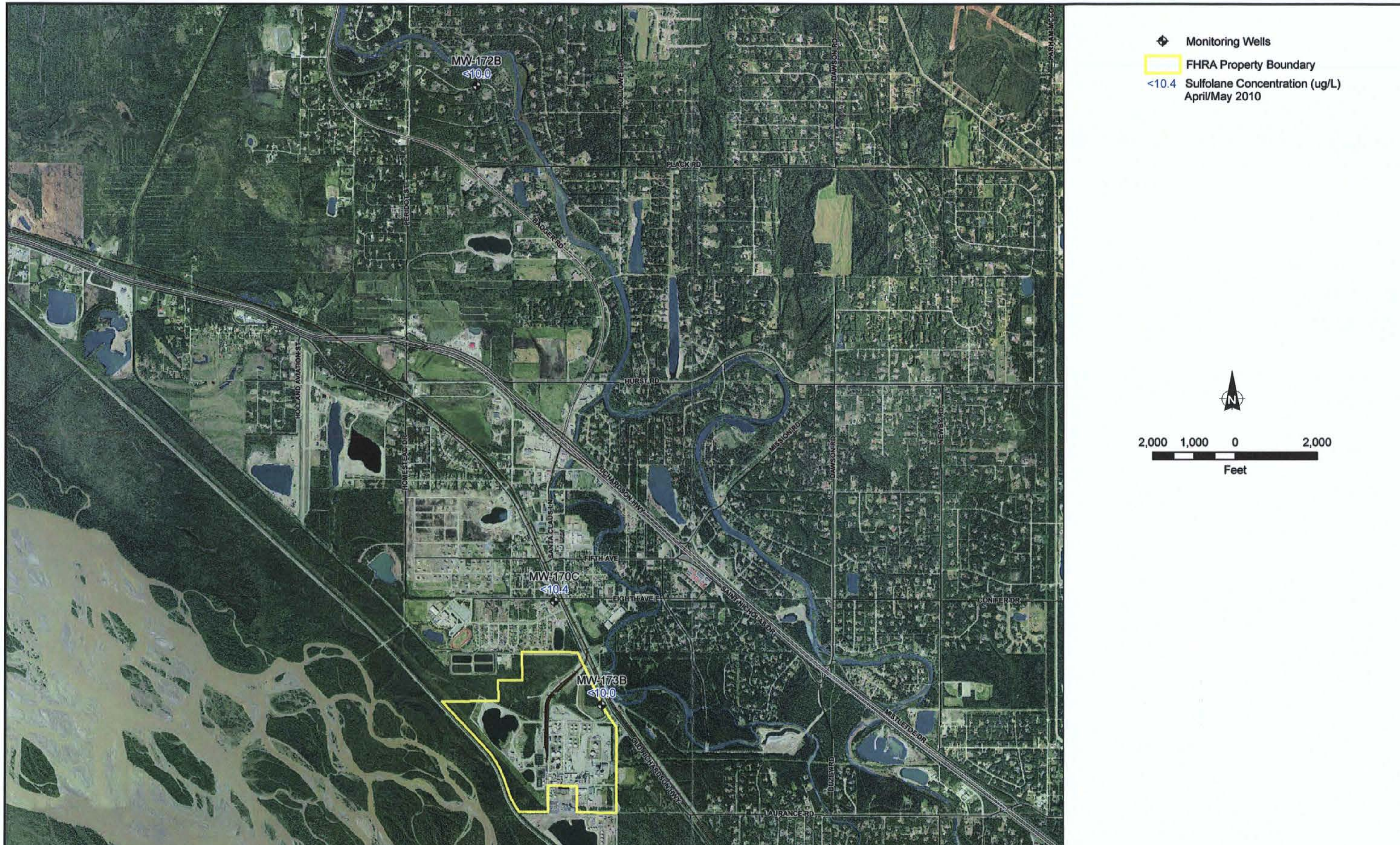

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Global Specialists in the Environment
Seattle, Washington

Source: Barr Engineering Company 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-16

SULFOLANE CONCENTRATIONS IN GROUNDWATER
90-160 FEET BELOW THE WATER TABLE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-16

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Proposed Monitoring Wells (Approximate)

Monitoring Well

Observation Well

Recovery Well

Sulfolane Concentration Isopleth (Dashed where estimated)

181 Sulfolane Concentration (ug/L) April 2010, except as noted

1 Data from March 2010

2 Data from February 2010

FHRA Property Boundary

N

2,000 1,000 0 2,000

Feet

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	**Source:** Barr Engineering Company 2010.	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-17 PROPOSED SULFOLANE MONITORING NETWORK, WATER TABLE, OFFSITE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-17

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Seattle, Washington

Source: Barr Engineering Company 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-18

PROPOSED SULFOLANE MONITORING NETWORK
15-55 FEET BELOW THE WATER TABLE

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-18

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ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	**Source:** Barr Engineering Company 2010.	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-19 PROPOSED SULFOLANE MONITORING NETWORK 55-90 FEET BELOW THE WATER TABLE
			Date: 5/7/12 — Drawn by: AES — 10:START-3\12040001\fig 2-19

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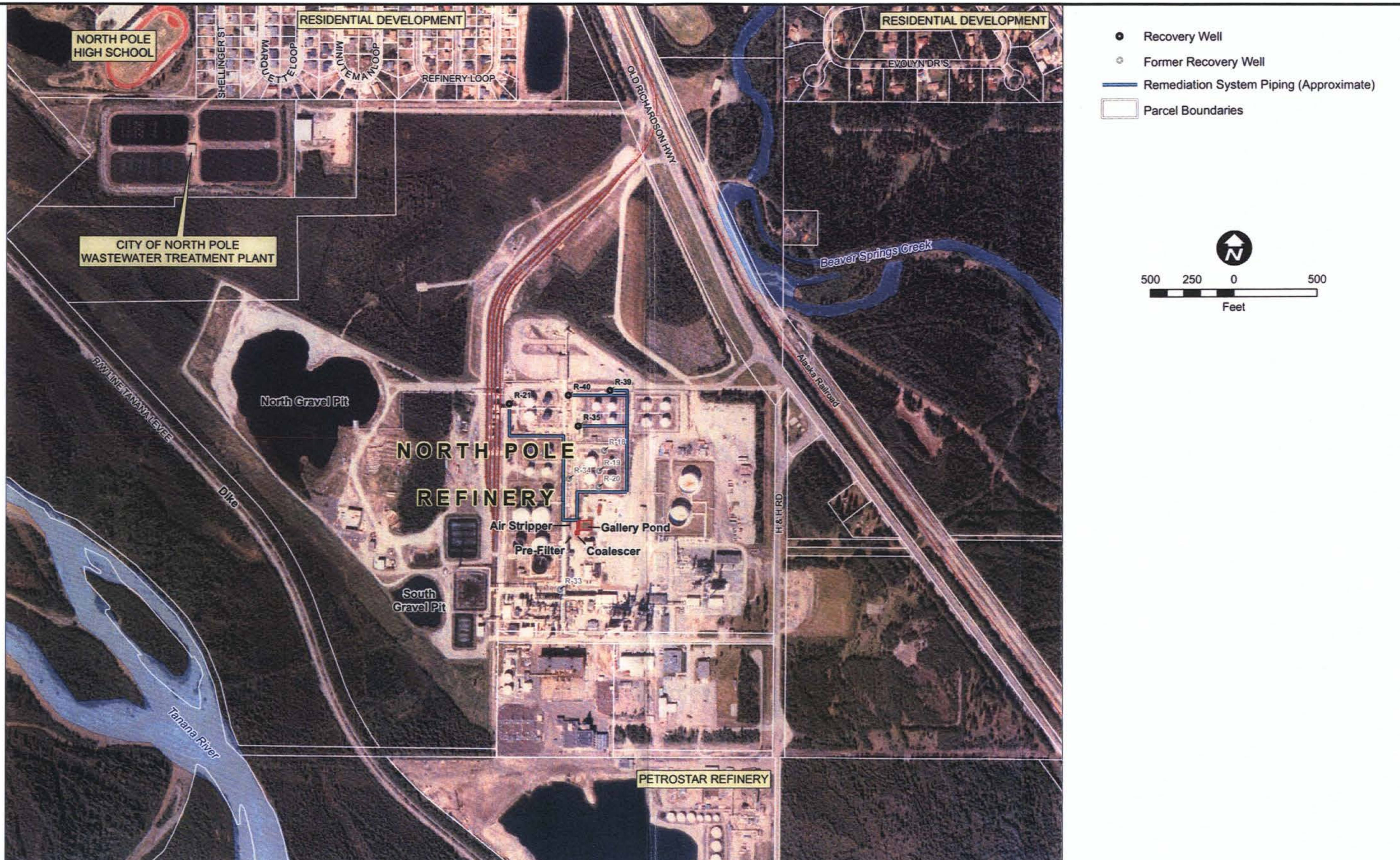

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Seattle, Washington

Source: Barr 2010.

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-20

REMEDIATION SYSTEM LAYOUT

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 2-20

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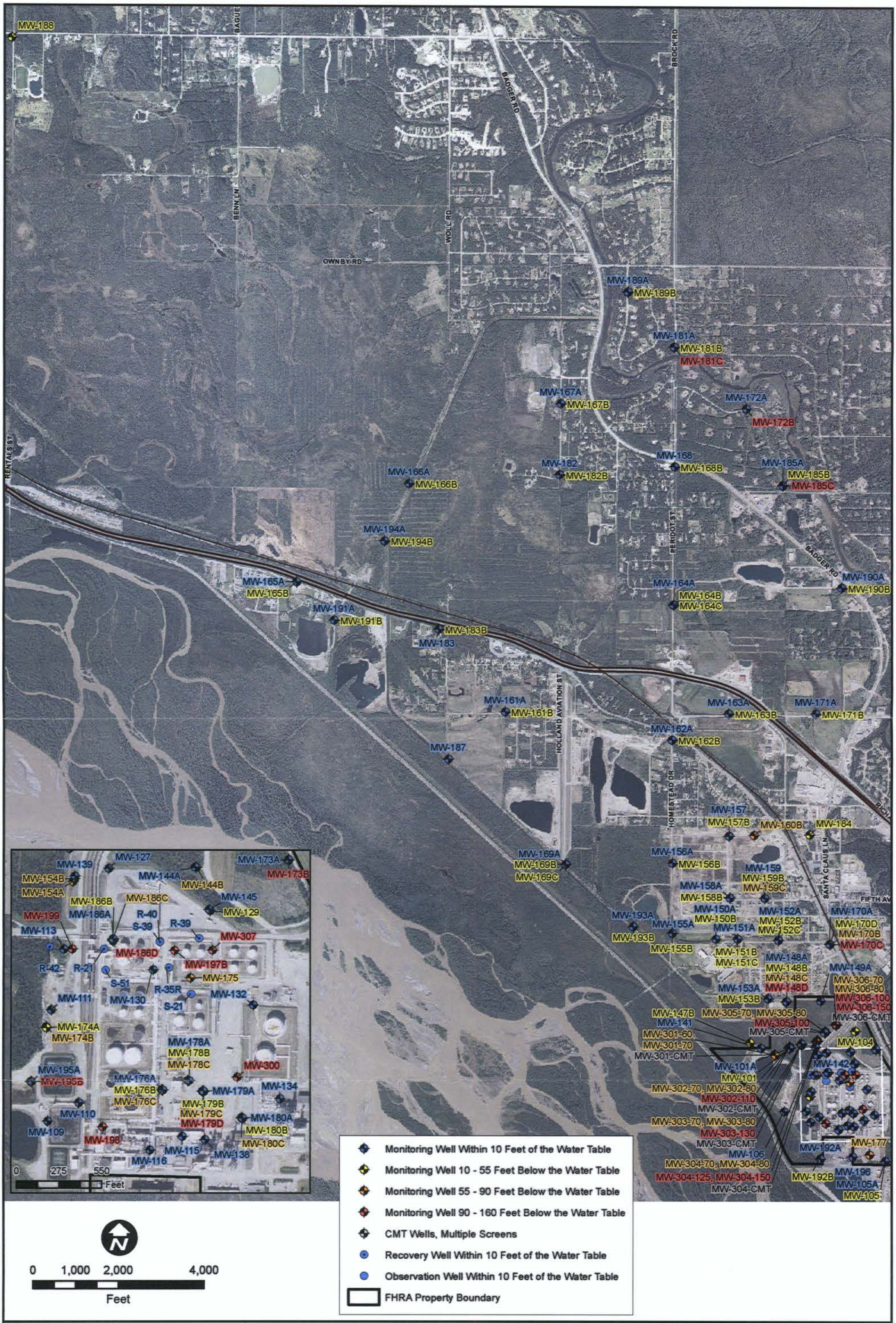

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska		Figure 2-21 SULFOLANE MONITORING NETWORK
	Source: Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES — 10:START-3\12040001\fig 2-21

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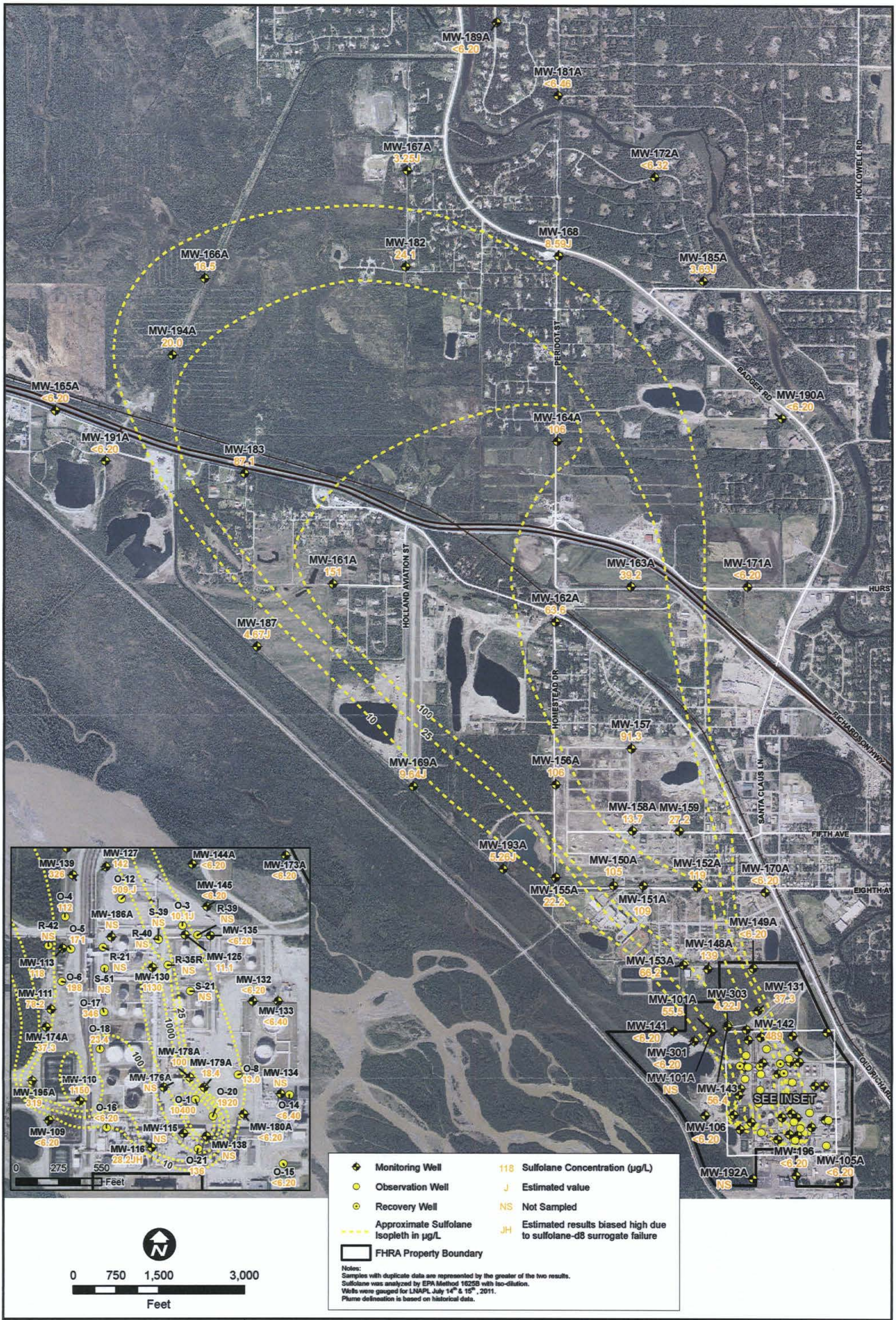

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-22 SULFOLANE CONCENTRATIONS AT THE WATER TABLE FOURTH QUARTER 2011
	Source: Barr Engineering Company 2012.	Date: 5/15/12 | Drawn by: AES | 10:START-3\12040001\fig 2-22

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Seattle, Washington

FLINT HILLS RESOURCES'
NORTH POLE REFINERY
North Pole, Alaska

Figure 2-23
SULFOLANE CONCENTRATIONS 10-55' BELOW THE WATER TABLE
FOURTH QUARTER 2011

Source: Barr Engineering Company 2012.

Date: 5/15/12

Drawn by: AES

10:START-3\12040001\fig 2-23

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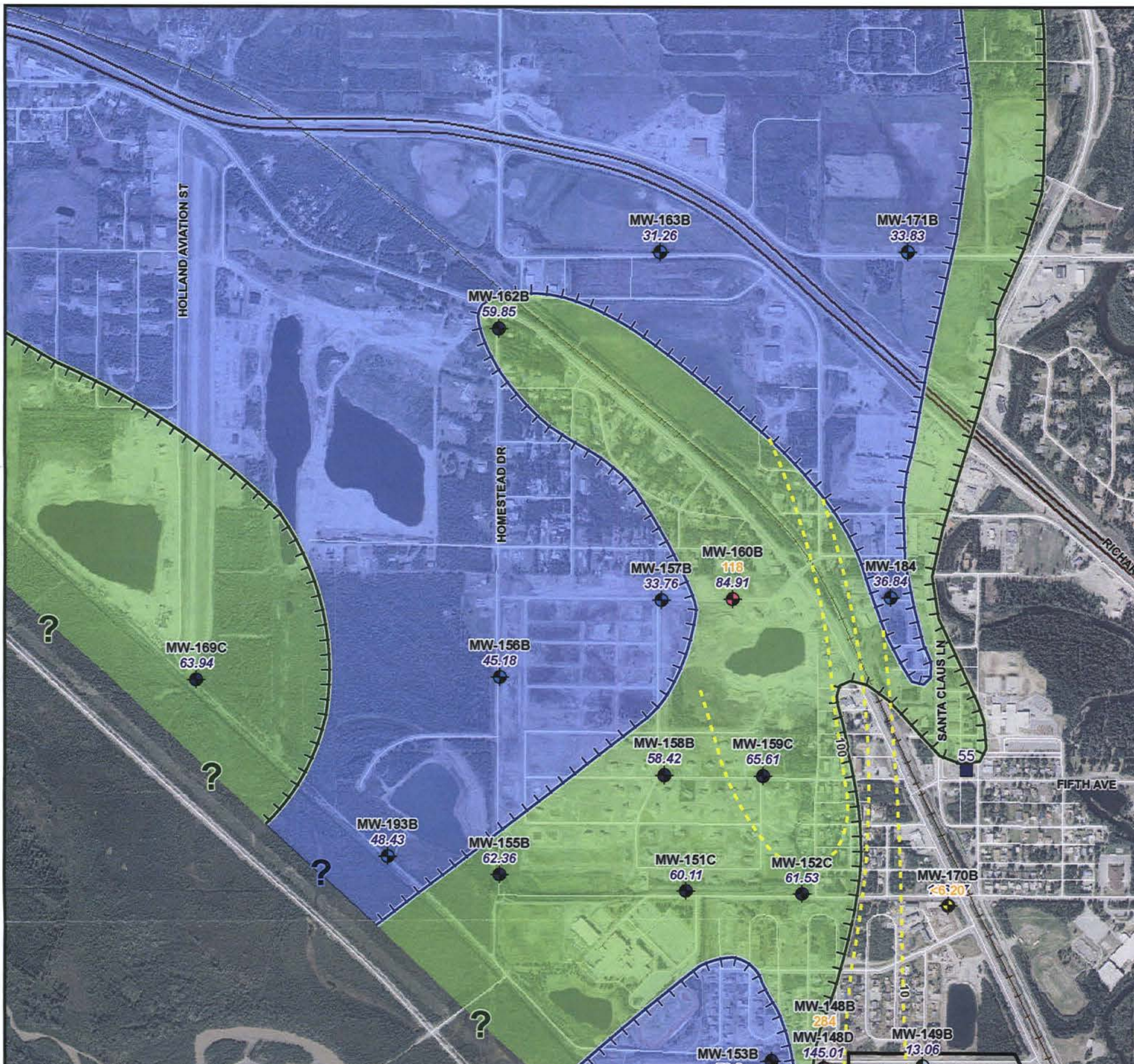

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-24 SULFOLANE CONCENTRATIONS 55-90' BELOW THE WATER TABLE FOURTH QUARTER 2011	
	Source: Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES — 10:START-3\12040001\fig 2-24

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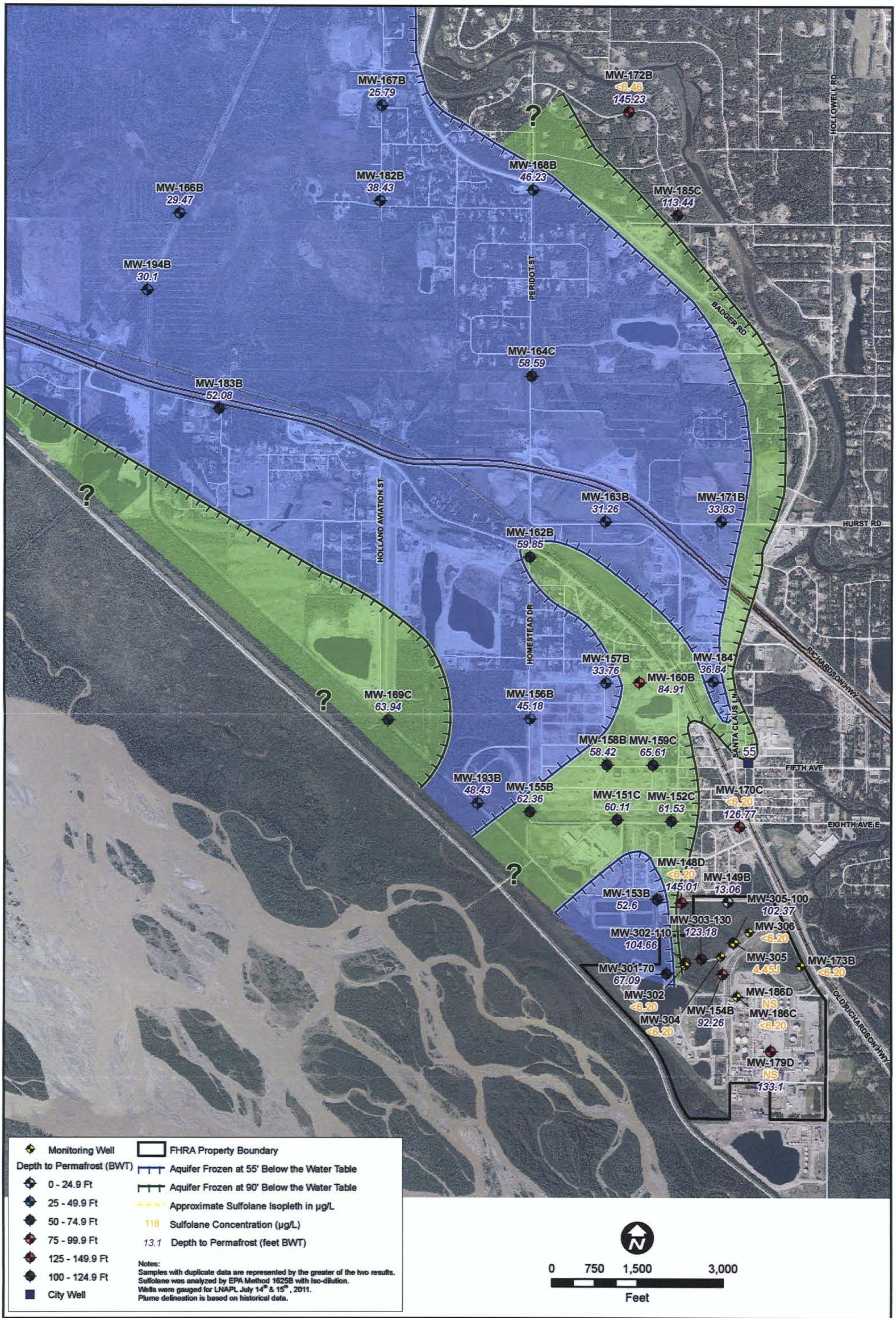

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-25 SULFOLANE CONCENTRATIONS 90-160' BELOW THE WATER TABLE FOURTH QUARTER 2011		
	Source: Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES	10:START-3\12040001\fig 2-25

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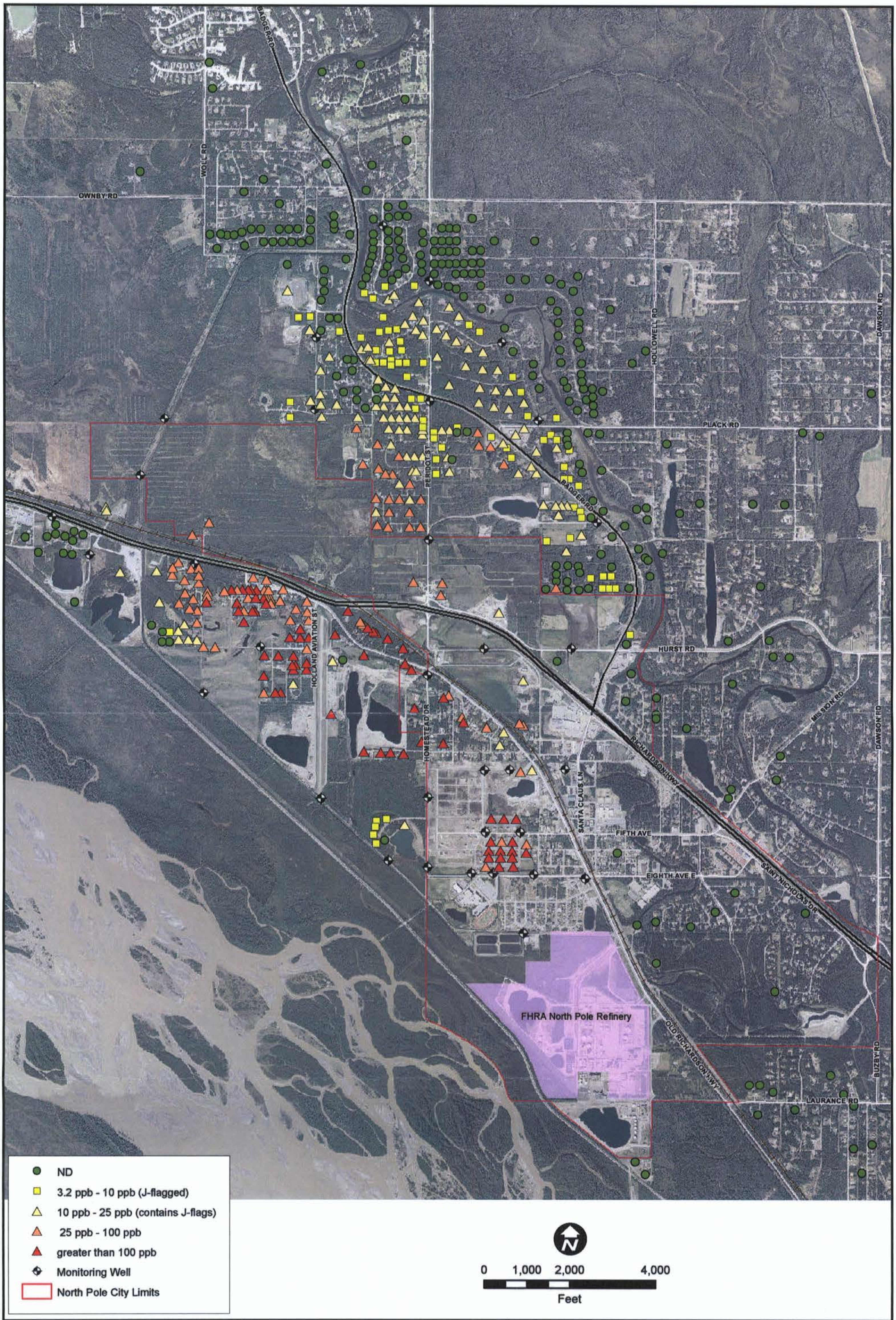

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-26 SULFOLANE CONCENTRATIONS FROM PRIVATE WELLS		
	Source: Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES	10:START-3\12040001\fig 2-26

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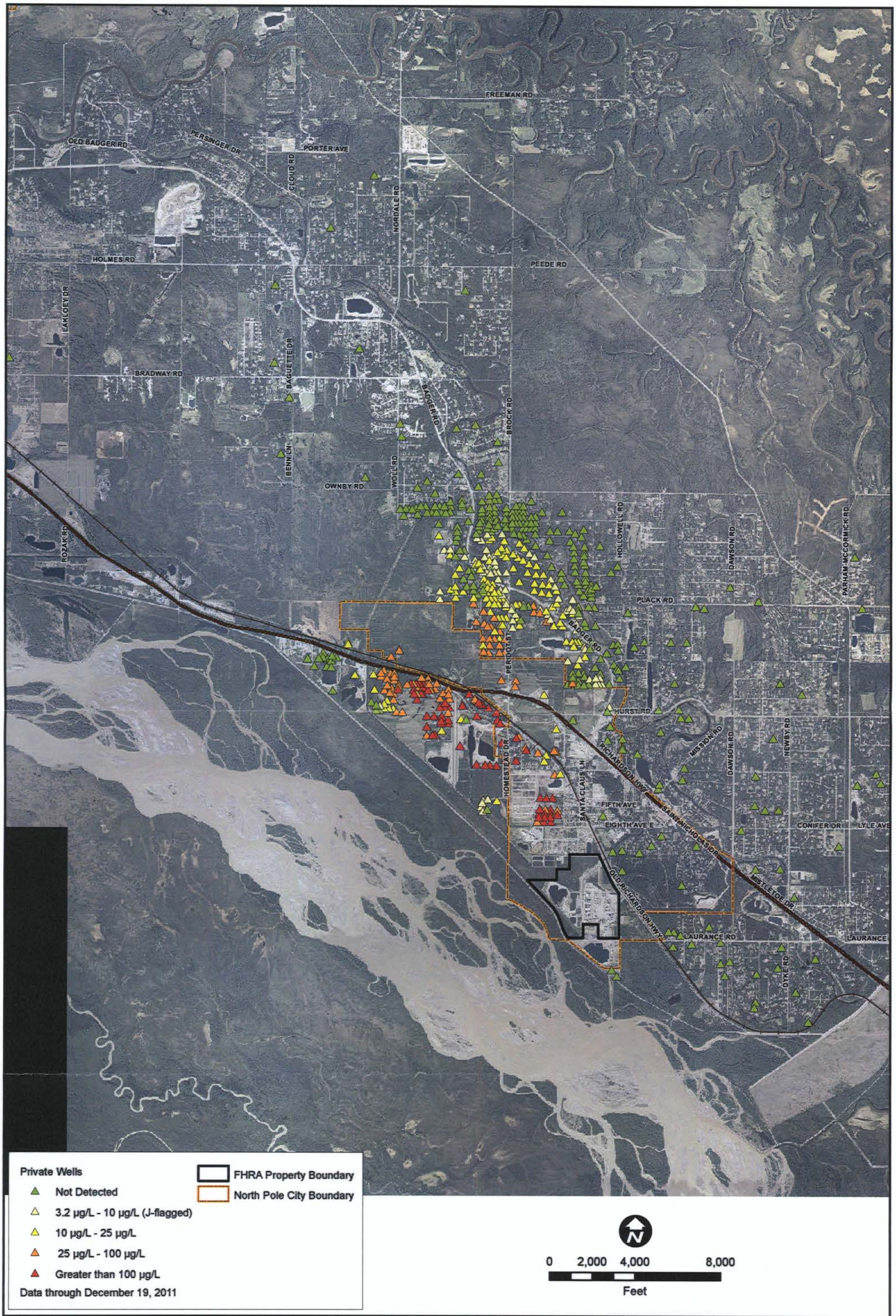

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NORTH POLE REFINERY
North Pole, Alaska

Figure 2-27
SULFOLANE CONCENTRATIONS FROM PRIVATE WELLS - EXTENDED VIEW

Source: Barr Engineering Company 2012.

Date:	Drawn by:	
5/15/12	AES	10:START-3\12040001\fig 2-27

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Notes:
Samples with duplicate data are represented by the greater of the two results.
Sulfolane was analyzed by EPA Method 1625B with Iso-dilution.
Wells were gauged for LNAPL July 14th & 15th, 2011.
Plume delineation is based on historical data.
Private well data from 2009-2011.

0 1,000 2,000 4,000
Feet

Private Wells
- Not Detected
- 3.2 µg/L - 10 µg/L (J-flagged)
- 10 µg/L - 25 µg/L
- 25 µg/L - 100 µg/L
- Greater than 100 µg/L

- Monitoring Well
- Approximate Sulfolane Isopleth in µg/L
- FHRA Property Boundary
- 118 Sulfolane Concentration (µg/L)
- J Estimated value
- NS Not Sampled

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Figure 2-28
SULFOLANE CONCENTRATIONS 10-55' BELOW THE WATER TABLE FROM PRIVATE WELLS – FOURTH QUARTER 2011

Source:	Barr Engineering Company 2012.	Date: 5/15/12	Drawn by: AES	10:START-3\12040001\fig 2-28

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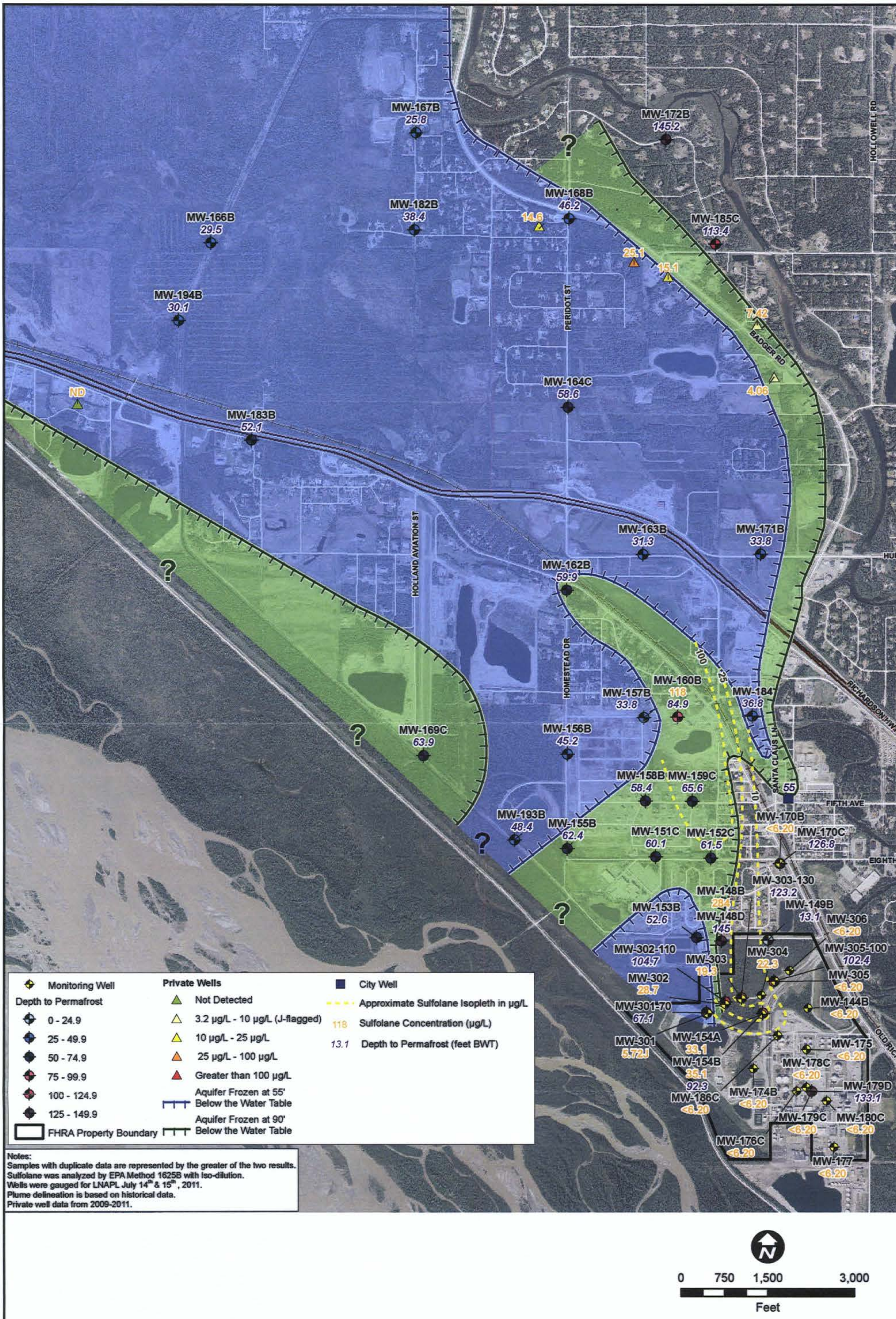

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Figure 2-29
SULFOLANE CONCENTRATIONS 55-90' BELOW THE WATER TABLE FROM PRIVATE WELLS – FOURTH QUARTER 2011

Source: Barr Engineering Company 2012.

Date: 5/15/12 | Drawn by: AES | 10:START-3\12040001\fig 2-29

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ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-30 SULFOLANE CONCENTRATIONS 90-160' BELOW THE WATER TABLE FROM PRIVATE WELLS – FOURTH QUARTER 2011
	Source: Barr Engineering Company 2012.	Date: 5/15/12 · Drawn by: AES · 10:START-3\12040001\fig 2-30

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ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 2-31 SULFOLANE CONCENTRATIONS >160' BELOW THE WATER TABLE FROM PRIVATE WELLS – FOURTH QUARTER 2011
	Source: Barr Engineering Company 2012.	Date: 5/15/12 · Drawn by: AES · 10:START-3\12040001\fig 2-31

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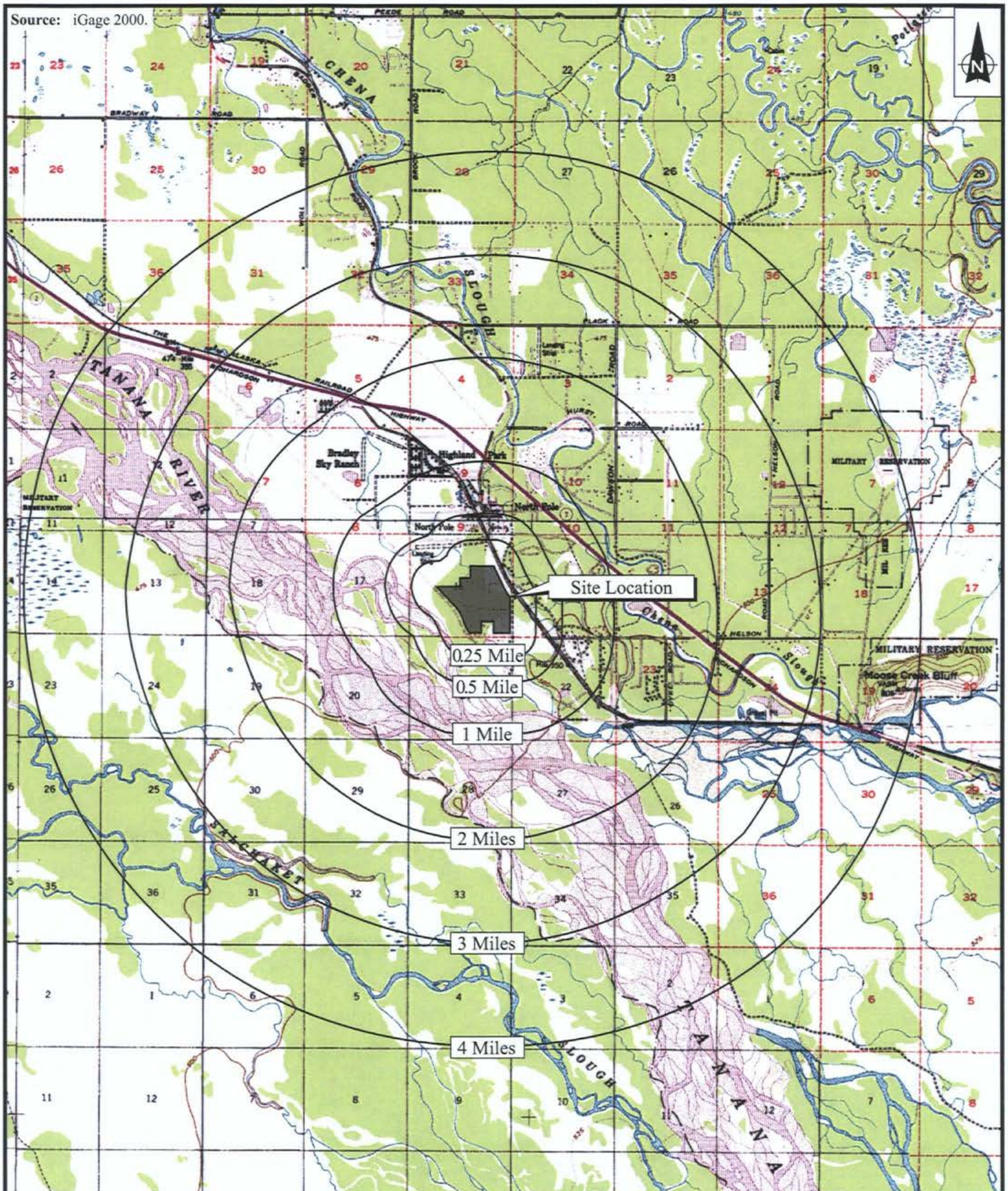

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0 .5 1
Approximate Scale in Miles

Figure 3-1

4-MILE MAP

Date:	Drawn by:	
5-7-12	AES	10:START-3\12040001\fig 3-1

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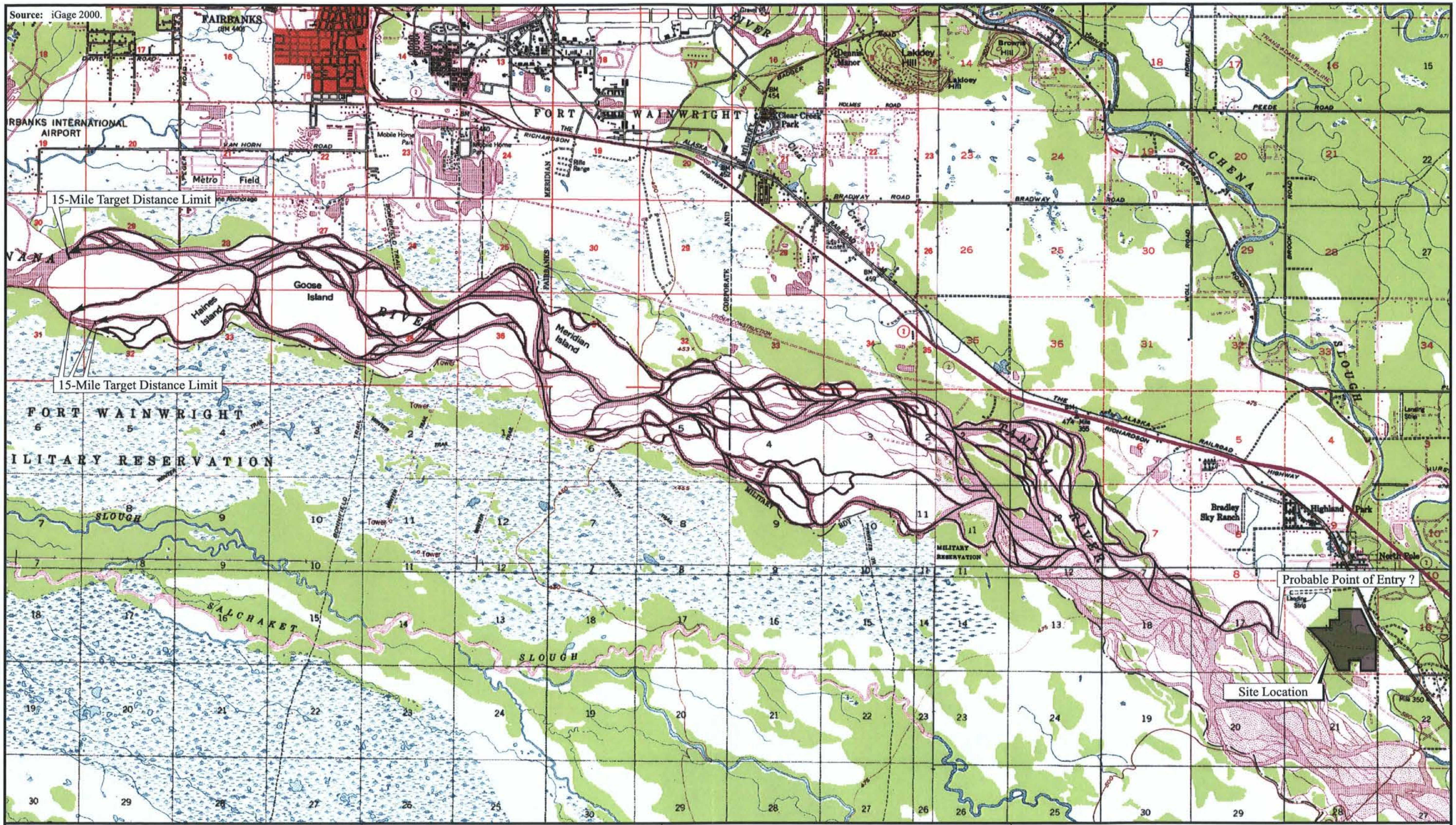

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Figure 3-2
15-MILE MAP

Date:	Drawn by:	
5/7/12	AES	10:START-3\12040001\fig 3-2

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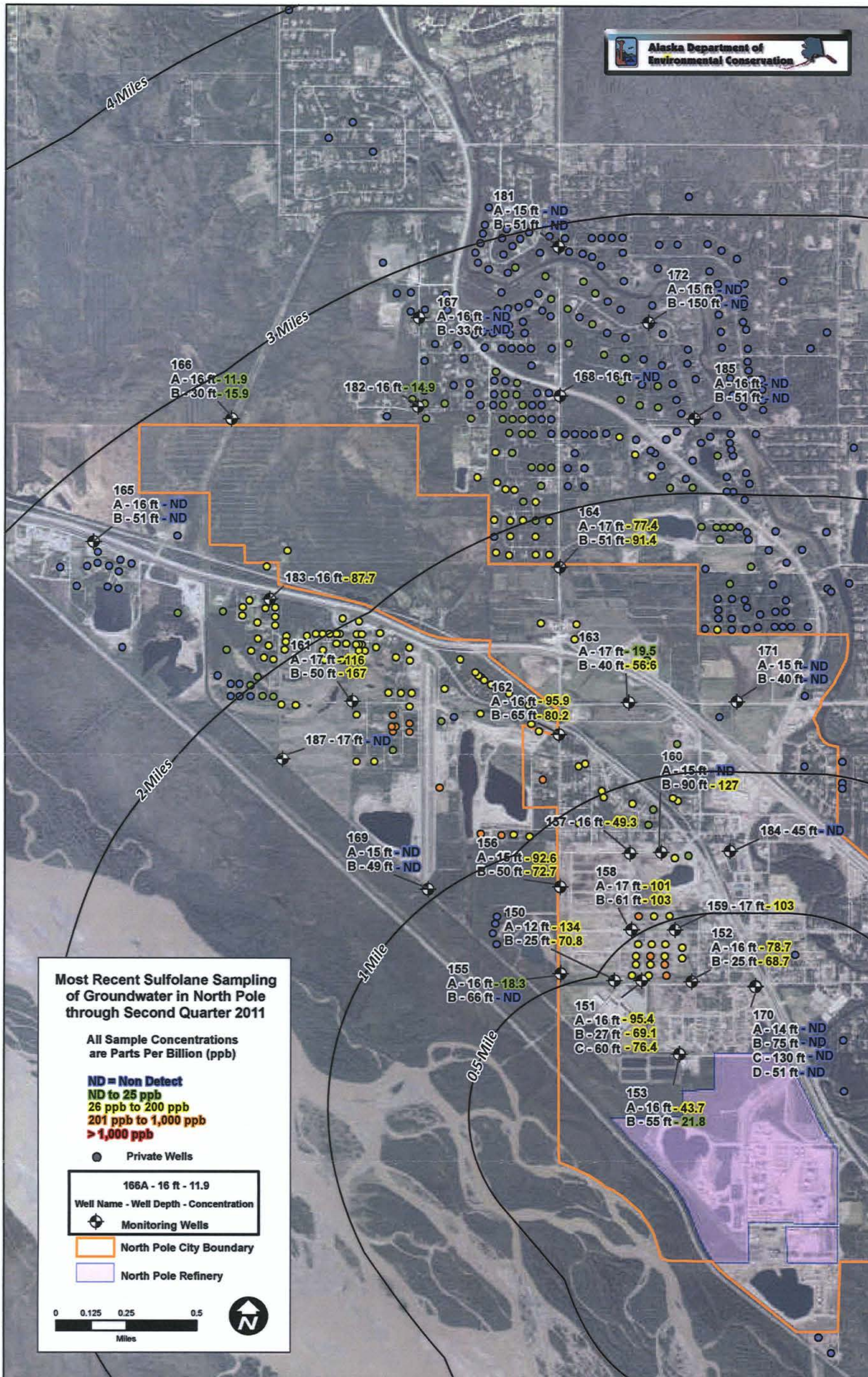

Base Map: BDL-GINA SPOT Image 5-17-2009, Data: Flint Hills-Shannon and Wilson, Created By: DEC-WB, Date: September 8, 2011

ecology and environment, inc. Global Specialists in the Environment Seattle, Washington	FLINT HILLS RESOURCES' NORTH POLE REFINERY North Pole, Alaska	Figure 3-3 SULFOLANE CONCENTRATION IN DOMESTIC AND MONITORING WELLS	
	Source: Shannon & Wilson, Inc. 2001.	Date: 5/15/12	Drawn by: AES — 10:START-3\12040001\fig 3-3

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